



## SECTION TWO IDENTIFYING HAZARDS

**STATE OF UTAH  
HAZARD MITIGATION PLAN**

**March 2011**

### Disaster History

#### Past Presidential Disaster Declarations

Utah's past presidential disaster declarations were examined having seven tying for fifty-seventh place with the Marshall Islands. What follows is a brief history and explanation of the presidential declarations:

##### **1983 Severe Storms, Landslides, Flooding**

The floods of April 10-June 25, 1983, affected 22 counties, or more than three-fourths of the State. On April 10, a landslide caused by precipitation dammed the Spanish Fork River, which then inundated the community of Thistle. The landslide, which resulted in damage totals of about \$200 million and a Presidential disaster declaration, was the most costly geologic phenomenon in Utah's history and the most costly landslide in U.S. history (*Utah Division of Comprehensive Emergency Management, 1985, p. 40*).

Rapid melting of the snow pack with maximum-of-record water content for June 1 (U.S. Soil Conservation Service, 1983) resulted in the largest and most widespread flooding in the State's history; peak discharges had recurrence intervals that exceeded 100 years on several streams. New discharge records were set on many others, such as Chalk Creek at Coalville. On June 23, the Delta-Melville-Abraham-Deseret Dam on the Sevier River near Delta failed as a result of the flooding on June 23, 1983, and released 16,000 acre-feet of water down the river. Two bridges were washed away, and the town of Deseret was inundated by as much as 5 feet of water (*Utah Division of Comprehensive Emergency Management, 1985, p. 41*).

Overall damage from the April 10- June 25, 1983, floods totaled \$621 million (Stephens, 1984, p. 20-36). No deaths were attributed to the floods.

##### **1984 Severe Storms, Mudslides, Landslides, Flooding**

The May 24, 1984, flooding of the Beaver River, near Beaver, and other flooding during the April 17- June 20, 1984, caused damages second in magnitude only to damages sustained in 1983. The primary cause of the flooding resulted from a combination of greater than average snow pack and above normal precipitation that continued throughout the spring. Peak discharges exceeded those in 1983 at some sites on the White, Bear, Jordan, and Beaver Rivers. Owing to severe flooding in 12 counties, a disaster was declared by the President. On May 14, rainfall caused a mudslide near the coal-mining town of Clear Creek that killed one person and injured another. The direct impact on people was considerably less in 1984 compared to 1983 because of mitigation measures implemented during the previous year. Total damage for floods and landslides was estimated to be \$41 million (*Utah Division of Comprehensive Emergency Management, 1985, p. 15*).

##### **1986 Heavy Rains, Snowmelt, Flooding**

On March 13, 1986 a Presidential Disaster Declaration was issued in connection to the Thistle Landslide. This landslide occurred in Spanish Fork Canyon creating a debris flow that blocked U.S. Highway 6, U.S. Highway 89, and the Denver and Rio Grande Western

Railroad track. The community of Thistle, located in Utah County, also experienced major losses. The Thistle landslide caused damage to roads, railways, homes, and businesses. The damages were in excess of \$200 million dollars. This was recorded as the worst landslide in Utah's history.

### **1989 Quail Creek Dam Failure**

The Quail Creek Dam, located in Washington County Utah, failed in the early hours of January 1, 1989. In the months prior to the failure, leakage of the dam was the result of the solubility of the gypsum in the soil, which dissolved some of the mechanisms used to transport water. Despite crew efforts, leakage of the dam continued to increase before the dam gave way. Failure of Quail Creek Dam resulted in losses to agriculture and livestock, as well as negative impact to public facilities, roads, bridges, and golf courses. 30 homes, 58 apartments and 9 businesses were flooded. In addition, a reduction in the population of wound fin minnow, a type of fish that is listed on the endangered species list, resulted from the dam failure. \$1,133,721 was provided for public assistance with a federal share of \$850,294.

### **1999 Salt Lake City Tornado**

On August 11, 1999, a tornado moved through downtown Salt Lake City. The tornado developed on the western side of downtown and moved northeast before expiring near Memory Grove Park. The tornado, ranked a strong F2 on the Fujita Scale, resulted in 1 death and 80 injuries. 300 buildings or houses were damaged, with 34 of the homes left uninhabitable. In addition, 500 trees were destroyed, as was a portion of Memory Grove Park. Total damage estimates for this storm are \$170 million and federal assistance was provided.

### **2005 Severe Storms and Flooding**

A stalled storm-system containing abundant moisture caused significant flooding in Washington and Kane Counties in Southern Utah between January 8-12, 2005. The storm brought rain and snow throughout much of the state causing additional precipitation to accumulate in areas already containing deep snow pack. Higher snowfall and water equivalent totals equaled 70" at Cedar Breaks, 60" at Kolob-Zion Park, and 58" at Alta. It is estimated that \$300 million dollars in damages was sustained along the Santa Clara and Virgin Rivers in Washington County. 30 homes were destroyed in the flood and another 20 homes were significantly damaged (NCDC, 2005). One fatality associated with this event resulted when a man and his wife in their vehicle were caught in floodwaters in the Red Cliff Recreation Area near the Quail Creek Reservoir. Six other injuries were reported. Two additional fatalities resulted from avalanches that occurred after the storm. The avalanches occurred primarily due to the considerable amount of wet, heavy snow that fell in the higher mountain elevations during these storms (UtahWeather.org). A Presidential Disaster Declaration was declared February 1, 2005.

### **2005 Utah Flood and Landslide**

During the period of April 28, 2005 until June 29, 2005, frequent rainfall events, warm spring temperatures, and abundant snowpack melting at accelerated rates resulted in significant flooding and numerous landslide events in nine Utah counties and two Indian

Reservations. According to the USGS, on April 28, 2005, localized precipitation, believed to be a rain-on-snow phenomenon, in southern Cache Valley caused flooding in the Lower Bear River basin. Peak discharge in the Little Bear River for this event exceeded the 100-year recurrence interval. Large peak discharges in spring of 2005 in the Duchesne and Sevier River basins were the result of near record snowpacks. (USGS, 2005). Total damages resulting from the flooding and landslide incidents are estimated to be over 2.9 million dollars. No deaths have been attributed to the flooding and landslide events. These events caused substantial damage to public and private property. In addition, many miles of roads were destroyed, bridges were damaged, and concerns of health risks such as vector born diseases transmitted by mosquitoes arose. A Presidential Disaster Declaration was declared on August 1, 2005 and included Beaver, Box Elder, Iron, Kane, Sevier, Tooele, Uintah, and Wasatch counties and the Uintah and Ouray Indian Reservations.

### **2010 Statewide Flooding**

During June of 2010 Utah faced severe statewide flooding caused by the springtime snowmelt. Multiple jurisdictions including: Salt Lake County, Summit County, Piute County, Uintah County, and the Uintah and Ouray Indian Reservation, all experienced damages due to the water and debris flow. Roads, bridges, homes, businesses, utilities, as well as other public and private facilities accrued damage. The total damages caused an estimated \$916,868 well below the threshold required for a Presidential Disaster Declaration. These damages were assessed through a Preliminary Damage Assessment (PDA) Team compromised of FEMA, State and local government.

## **Hazard Identification**

Borrowing a principle from geology “the past is the key to the future” it is important to understand past events or a states disaster history in order to foresee future problems. A chronological history was assembled for each hazard, which can occur in Utah. This work was primarily conducted by each AOG with input from the U.S. Army Corps of Engineers and the Utah DHLS. Disaster history’s were compiled from numerous sources including but not limited to: Flood Insurance Studies, newspaper articles, the University of Utah Seismograph Stations, interviews, surveys, past mitigation plans, libraries, microfilm, Sheldus, and the Utah Historical Society.

Several recent and not so recent studies, played into identifying hazards. These studies included hydrologic, meteorological, drought, and new research on seismicity, particularly along the Wasatch Front. Many of these studies have shed new light on past events; in some cases we have found, there is a higher risk then previously thought. For example, a seismic study being



Figure I-1 Large trench dug in Mapleton as part of the earthquake recurrence interval study. Photo taken by Bob Carey.

headed by Sue Olig on the Wasatch Fault contains preliminary results indicating a shorter recurrence interval for events along the Wasatch Fault.

As a result of this study the state plan addressed the following major natural hazards:

- Earthquake, including association hazards of fault rupture, liquefaction, etc.
- Flood
- Landslide, including debris flow
- Dam Failure
- Wildfires
- Drought
- Severe Weather includes winter storm, high wind, avalanche, and tornado.

Based on the hazard history and profiles of the aforementioned hazards, the recurrence interval and hazard frequency were determined (see Table I-1). The recurrence interval was calculated by dividing the number of years observed for each hazard by the number of events reported. For example, there are 127 documented tornadoes during a 60-year period. This information provides a recurrence interval of 60/127 or 0.47. The hazard frequency was calculated by dividing the number of events observed by the number of years. For example, 79 wildfires larger than 5000 acres divided by 23 years indicates that an average of 3.34 large wildfires occur in Utah in any given year.

### Local Hazard Mitigation Plans (LHMP)

Local Hazard Mitigation Plans (LHMP) completed through the Association of Governments (AOG) in conjunction with local jurisdictions were reviewed to see if any hazards were identified at the local level which warranted review at the state level. Each county assigns a Frequency and a severity to each hazard they have identified. Frequency is the likelihood of the disaster occurring in the county. Severity is the potential magnitude the disaster affects the county.

### **LHMP - Frequency and Severity**

| Frequency              |  |
|------------------------|--|
| Highly Likely/Frequent | Near 100% probability in next year.  |
| Likely/Occasional      | Between 10 and 100% probability in next year, or at least one chance in next 10 years  |
| Possible/Rare          | Between 1 and 10% probability in next year, or, at least one chance in next 100 years. |
| Unlikely/Never         | Less than 1% probability in next 100 years   |
| Severity               |  |
| Catastrophic/Severe    | More than 50% of County  |
| Critical/Moderate      | 25 to 50%  |
| Limited                | 10 to 25%  |
| Negligible             | Less than 10%  |

## Identifying Hazards

Based on the frequency and severity each LHMP assigned each hazard, the SHMPC, assigned a score to rank each hazard by county. The SHMPC added the scores up to determine which hazards the counties viewed the highest concern. It's important to note that each county mentioned drought in the LHMP but few assigned a frequency and severity. This is understandable considering drought characteristics are difficult to rank. Not all LHMPs assigned frequency and severity the same way. Some LHMPs used severe to moderate and rare to frequent. The SHMPC used their best judgment to determine their intent.

### LHMP - Frequency Severity Ranking

|                     |                          |
|---------------------|--------------------------|
| 3 Catastrophic      | 3 Highly Likely/Frequent |
| 2 Critical/Moderate | 2 Likely/Occasional      |
| 1 Limited           | 1 Possible/Rare          |
| 0 Neglible          | 0 Unlikely/Never         |

### LHMP - Hazard Frequency and Severity Assessment Based on County Population

| County By Population (highest to lowest) | Earthquake | Flooding | Landslide | Wildfire | Problem Soil | Dam Failure | Severe Weather | Insect Infestation | Radon |
|--|------------|----------|-----------|----------|--------------|-------------|----------------|--------------------|-------|
| Salt Lake                                | 5          | 4        | 3         | 4        | 2            | 3           | 4              | 3                  | 3     |
| Utah                                     | 4          | 4        | 4         | 5        | 4            | 4           | 4              | 6                  | 0     |
| Davis                                    | 5          | 3        | 4         | 5        | 1            | 4           | 4              | 3                  | 3     |
| Weber                                    | 5          | 3        | 3         | 4        | 2            | 4           | 4              | 3                  | 3     |
| Washington                               | 3          | 5        | 5         | 4        | 0            | 0           | 4              | 2                  | 3     |
| Cache                                    | 4          | 4        | 4         | 6        | 0            | 4           | 4              | 0                  | 0     |
| Tooele                                   | 5          | 2        | 3         | 4        | 2            | 3           | 4              | 3                  | 3     |
| Box Elder                                | 4          | 4        | 5         | 5        | 0            | 4           | 4              | 3                  | 3     |
| Iron                                     | 3          | 5        | 5         | 4        | 0            | 0           | 4              | 2                  | 3     |
| Summit                                   | 4          | 5        | 4         | 5        | 4            | 5           | 4              | 6                  | 0     |
| Uintah                                   | 3          | 4        | 2         | 5        | 0            | 3           | 4              | 6                  | 0     |
| Sanpete                                  | 4          | 3        | 4         | 5        | 2            | 2           | 5              | 0                  | 0     |
| Wasatch                                  | 4          | 4        | 4         | 4        | 4            | 4           | 4              | 6                  | 0     |
| Sevier                                   | 4          | 3        | 2         | 5        | 2            | 3           | 5              | 0                  | 0     |
| Carbon                                   | 4          | 4        | 3         | 4        | 5            | 4           | 3              | 3                  | 0     |
| Duchesne                                 | 3          | 3        | 3         | 6        | 0            | 3           | 4              | 6                  | 0     |
| San Juan                                 | 4          | 3        | 0         | 4        | 0            | 4           | 3              | 3                  | 0     |
| Millard                                  | 4          | 4        | 2         | 5        | 2            | 2           | 5              | 0                  | 0     |
| Emery                                    | 4          | 2        | 1         | 0        | 0            | 2           | 3              | 0                  | 0     |
| Grand                                    | 4          | 5        | 3         | 4        | 4            | 4           | 3              | 0                  | 0     |
| Juab                                     | 4          | 3        | 2         | 5        | 2            | 2           | 5              | 0                  | 0     |
| Morgan                                   | 5          | 4        | 5         | 5        | 2            | 5           | 4              | 3                  | 3     |
| Kane                                     | 3          | 5        | 5         | 5        | 0            | 0           | 4              | 2                  | 3     |
| Beaver                                   | 3          | 5        | 5         | 4        | 0            | 0           | 4              | 2                  | 3     |
| Garfield                                 | 3          | 5        | 5         | 4        | 0            | 0           | 4              | 2                  | 3     |
| Wayne                                    | 4          | 3        | 2         | 2        | 2            | 2           | 5              | 0                  | 0     |
| Rich                                     | 4          | 3        | 3         | 5        | 0            | 4           | 4              | 0                  | 0     |
| Piute                                    | 4          | 3        | 2         | 5        | 0            | 2           | 5              | 0                  | 0     |
| Daggett                                  | 4          | 4        | 4         | 6        | 0            | 4           | 4              | 6                  | 0     |

Previous State Hazard Mitigation Plans were reviewed to see if perceived vulnerability to hazards had changed over the years and if so how. This study of almost 20 years of plans, showed vulnerability had changed over time but the hazards had not. Following flooding in 1983 and 1984 large investments were made in mitigation. As proved this year by the spring 2010 flooding this investment reduced the vulnerability to similar flood events in Salt Lake and Wasatch Counties, yet increased population and the conversion of agricultural land to residential development still makes flooding despite the mitigation, a hazard in Utah.

**Table I-1 Utah Hazard Recurrence and Frequency**

| Hazard                      | Number of Events | Years in Record | Recurrence Interval (years) | Hazard Frequency and Probability/Year |
|-----------------------------|------------------|-----------------|-----------------------------|---------------------------------------|
| Droughts*                   | 60               | 115             | 1.917                       | 52%                                   |
| Earthquakes**               | 31               | 159             | 5.129                       | 19.50%                                |
| Landslides                  | N/A              | N/A             | N/A                         | N/A                                   |
| Floods***                   | 18               | 126             | 7                           | 14%                                   |
| Tornadoes (all)             | 127              | 60              | 0.47                        | 212%                                  |
| Avalanches (fatalities)     | 100              | 59              | 0.59                        | 169%                                  |
| Wildfires (>5000 acres)     | 79               | 23              | 0.291                       | 343%                                  |
| Thunderstorms and Lightning | 829              | 60              | 0.072                       | 1382%                                 |

\*PDSI, Drought Years as indicated by the USGS

\*\* Magnitude 5.0 or larger Data from UGS and University of Utah Seismography Station.

\*\*\* Only large flooding events reported by the USGS and FEMA.

Landslide recurrence intervals cannot be predicted because landslides often have recurrent movement with the same landslides moving each year depending on climate.

Tornado and Avalanche data courtesy of the Utah National Weather Service.

Thunderstorm and Lightning data courtesy of NOAA National Climate Data Center.

<http://www.ncdc.noaa.gov/temp-and-precip/time-series/?parameter=pdsi&month=10&year=2010&filter=1&state=42&div=0>

<http://www.quake.utah.edu/EQCENTER/QUARTERLY/quarterly.htm>

<http://www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwevent~storms>

<http://www.wr.noaa.gov/slc/climate/tornado.php>

<http://utahavalanchecenter.org/resources/stats>

[http://www.wr.noaa.gov/slc/projects/disasters/avalanche\\_deaths.php](http://www.wr.noaa.gov/slc/projects/disasters/avalanche_deaths.php)

<http://www.fema.gov/femaNews/disasterSearch.doc>

**Table I-2 Utah Disaster Loss Data 1970 through 2010**

| Event     | Injuries | Fatalities | Property Damage* | Crop Damage*    |
|-----------|----------|------------|------------------|-----------------|
| Hail      | 89.01    | 1.00       | \$2,616,000.04   | \$2,452,350.01  |
| Fog       | 53.06    | 13.06      | \$1307000.04     | 0.00            |
| Flooding  | 42.00    | 20.95      | \$402,019,000.26 | \$51,035,300.04 |
| Avalanche | 18.02**  | 32.90**    | \$100,000.02     | 0.00            |
| Lightning | 48.00**  | 40.00**    | \$2,435,050.04   | \$6,000.00      |
| Tornado   | 89       | 1          | \$173,632,050.00 | \$607,750.00    |

## Identifying Hazards

|                     |          |        |                  |                 |
|---------------------|----------|--------|------------------|-----------------|
| Severe Thunderstorm | 37       | 13     | \$28,086,000.04  | \$914899.99     |
| Wildfire            | 0        | 10     | \$770,000.00     | \$40,000.00     |
| Winter weather      | 879.03   | 79.79  | \$63,884,550.60  | \$6,681,599.73  |
| Wind                | 216.14   | 18.98  | \$77,251,649.78  | \$2,623,351.02  |
| Total               | 1,471.26 | 230.68 | \$752,101,300.82 | \$64,361,250.79 |

Source: www.sheldus.org

\* Totals are not inflation adjusted

\*\* More accurate data exist

## Local Risk Assessments

Each of the seven Local Hazard Mitigation Plans (LHMP) produced by the Association of Governments were reviewed by the State Hazard Mitigation Planning Committee (SHMPC). Two of the LHMP's have been updated and approved by FEMA since the last update of the SHMP, Wasatch Front Regional Council (WFRC) and Bear River Association of Government (BRAG) Mountainland Association of Government (MAG) and Five County Mitigation plans are in the process of being updated and the SHMPC used their updated plans. The SHMPC used all LHMPs to review local risk assessments. Some of the LHMP risk assessment data was added into the SHMP to show areas with greater risk at a local level and to use as examples of the type of data in the LHMP. The SHMPC reviewed the LHMP risk assessments to aid in determining overall state risk. LHMP loss estimates were used in the SHMP flood loss estimates.

**Table I-3 County Disaster Losses 1970 through 2010**

| County    | Injuries | Fatalities | Property Damage* | Crop Damage*   |
|-----------|----------|------------|------------------|----------------|
| Beaver    | 27.21    | 2.24       | \$14,839,340.89  | \$2,435,588.22 |
| Box Elder | 90.54    | 6.73       | \$21,558,855.34  | \$1,801,004.56 |
| Cache     | 57.00    | 8.10       | \$20,724,862.37  | \$2,979,230.89 |
| Carbon    | 30.62    | 6.97       | \$15,635,355.30  | \$2,443,602.40 |
| Daggett   | 8.00     | 1.91       | \$12,188,230.84  | \$35,467.59    |
| Davis     | 77.16    | 4.78       | \$25,152,923.37  | \$3,159,037.79 |
| Duchesne  | 27.29    | 8.72       | \$15,456,339.35  | \$2,434,921.89 |
| Emery     | 35.58    | 6.76       | \$13,531,585.34  | \$154,867.98   |
| Garfield  | 19.52    | 6.11       | \$15,494,610.23  | \$2,480,320.36 |
| Grand     | 11.49    | 4.37       | \$11,571,145.20  | \$23,126.02    |
| Iron      | 43.48    | 2.07       | \$16,220,890.52  | \$3,079,570.27 |
| Juab      | 49.54    | 8.05       | \$15,857,563.68  | \$2,825,642.84 |
| Kane      | 18.39    | 9.11       | \$12,969,607.85  | \$158,117.98   |
| Millard   | 47.94    | 2.22       | \$14,961,345.13  | \$2,802,161.94 |
| Morgan    | 44.65    | 5.06       | \$16,136,360.82  | \$2,806,059.97 |
| Piute     | 15.66    | 1.78       | \$12,288,077.55  | \$67,701.32    |
| Rich      | 27.27    | 3.94       | \$15,779,491.33  | \$2,412,127.95 |
| Salt Lake | 240.05   | 34.38      | \$208,732,797.46 | \$4,070,415.28 |
| San Juan  | 11.62    | 13.76      | \$16,750,854.82  | \$2,839,675.88 |
| Sanpete   | 33.20    | 4.93       | \$18,519,516.98  | \$3,458,110.82 |
| Sevier    | 17.66    | 1.70       | \$14,798,060.45  | \$2,859,019.08 |
| Summit    | 49.61    | 18.35      | \$16,249,248.76  | \$2,447,057.79 |
| Tooele    | 60.91    | 6.53       | \$22,260,245.11  | \$2,507,739.41 |

## Identifying Hazards

|            |        |       |                  |                |
|------------|--------|-------|------------------|----------------|
| Uintah     | 13.29  | 6.91  | \$16,385,807.06  | \$2,488,028.39 |
| Utah       | 107.97 | 14.97 | \$240,244,245.87 | \$4,138,356.94 |
| Wasatch    | 41.40  | 11.97 | \$13,116,504.36  | \$63,488.74    |
| Washington | 32.51  | 6.07  | \$33,139,0913.61 | \$2,909,812.03 |
| Wayne      | 18.25  | 1.84  | \$20,447,807.20  | \$53,367.98    |
| Weber      | 79.38  | 4.31  | \$29,815,995.26  | \$3,127,478.53 |

Source: www.sheldus.org

\* Totals are not inflation adjusted

| <b>Loss Estimates - FEMA HAZUS FLOOD 100-Year Summary</b> |                                      |                                     |                              |                                     |                              |
|---|--------------------------------------|-------------------------------------|------------------------------|-------------------------------------|------------------------------|
| <b>Returns for Buildings by County in Utah</b>            |                                      |                                     |                              |                                     |                              |
| <b>County</b>   | <b>Building<br/>Damage<br/>Count</b> | <b>Building<br/>Damage<br/>Loss</b> | <b>Building<br/>Exposure</b> | <b>Contents<br/>Damage<br/>Loss</b> | <b>Contents<br/>Exposure</b> |
| Beaver  | 0                                    | \$639                               | \$322,634                    | \$459                               | \$206,822                    |
| Box Elder   | 96                                   | \$8,497                             | \$2,212,848                  | \$8,691                             | \$1,460,525                  |
| Cache   | 179                                  | \$19,690                            | \$4,821,157                  | \$22,683                            | \$3,342,576                  |
| Carbon  | 166                                  | \$13,447                            | \$1,112,691                  | \$16,408                            | \$728,473                    |
| Daggett   | 0                                    | \$87                                | \$87,296                     | \$57                                | \$50,334                     |
| Davis   | 77                                   | \$11,604                            | \$13,227,621                 | \$11,820                            | \$8,459,340                  |
| Duchesne  | 31                                   | \$5,662                             | \$712,471                    | \$7,282                             | \$487,550                    |
| Emery   | 16                                   | \$2,958                             | \$525,424                    | \$2,646                             | \$333,091                    |
| Garfield  | 11                                   | \$2,489                             | \$349,891                    | \$3,062                             | \$216,840                    |
| Grand   | 117                                  | \$10,922                            | \$527,165                    | \$13,886                            | \$363,805                    |
| Iron  | 118                                  | \$14,878                            | \$1,901,503                  | \$28,600                            | \$1,297,448                  |
| Juab  | 30                                   | \$3,166                             | \$453,756                    | \$3,840                             | \$341,677                    |
| Kane  | 11                                   | \$2,972                             | \$435,557                    | \$3,473                             | \$284,597                    |
| Millard   | 26                                   | \$6,468                             | \$643,452                    | \$8,700                             | \$446,618                    |
| Morgan  | 90                                   | \$6,487                             | \$419,852                    | \$7,303                             | \$278,426                    |
| Piute   | 3                                    | \$683                               | \$86,574                     | \$901                               | \$52,376                     |
| Rich  | 0                                    | \$739                               | \$283,898                    | \$868                               | \$161,567                    |
| Salt Lake   | 4123                                 | \$410,727                           | \$56,227,118                 | \$648,085                           | \$38,131,153                 |
| San Juan  | 80                                   | \$6,459                             | \$562,002                    | \$4,306                             | \$349,671                    |
| Sanpete   | 32                                   | \$7,049                             | \$1,067,962                  | \$13,060                            | \$769,914                    |
| Sevier  | 13                                   | \$2,164                             | \$937,444                    | \$2,921                             | \$615,885                    |
| Summit  | 51                                   | \$9,315                             | \$3,204,951                  | \$11,288                            | \$1,942,472                  |
| Tooele  | 42                                   | \$4,150                             | \$2,186,117                  | \$4,277                             | \$1,335,612                  |
| Uintah  | 22                                   | \$5,334                             | \$1,204,836                  | \$6,143                             | \$815,173                    |
| Utah  | 506                                  | \$58,587                            | \$17,905,687                 | \$87,433                            | \$11,929,069                 |
| Wasatch   | 21                                   | \$5,496                             | \$1,110,532                  | \$11,795                            | \$710,009                    |
| Washington  | 1279                                 | \$117,793                           | \$5,311,696                  | \$107,027                           | \$3,470,694                  |
| Wayne   | 19                                   | \$1,977                             | \$147,504                    | \$1,346                             | \$91,347                     |
| Weber   | 318                                  | \$25,818                            | \$11,142,813                 | \$30,182                            | \$7,182,636                  |

Source: FEMA Region VIII; 2011

| Loss Estimates - FEMA HAZUS EARTHQUAKE<br>Direct Economic Losses For Buildings   |  |  |                             |
|--|--|--|-----------------------------|
| Damage   | Building Damage                              | Non-Structural Damage                                | Total \$\$ loss             |
| County   |  |  |                             |
| Utah   | \$1,417                                      | \$5,018  | \$10,801                    |
| Wayne  | \$3  | \$8  | \$21                        |
| Sanpete  | \$45   | \$154  | \$352                       |
| Washington   | \$254  | \$723  | \$1,740                     |
| Beaver   | \$17   | \$53   | \$126                       |
| Wasatch  | \$43   | \$146  | \$319                       |
| Box Elder  | \$203  | \$689  | \$1,474                     |
| Sevier   | \$44   | \$148  | \$333                       |
| Emery  | \$22   | \$63   | \$146                       |
| Piute  | \$6  | \$17   | \$42                        |
| Kane   | \$14   | \$38   | \$100                       |
| Tooele   | \$101  | \$349  | \$738                       |
| Carbon   | \$38   | \$110  | \$274                       |
| Grand  | \$4  | \$11   | \$32                        |
| Salt Lake  | \$7,033                                      | \$25,274   | \$54,212                    |
| Juab   | \$20   | \$66   | \$151                       |
| Weber  | \$1,089                                      | \$3,812  | \$8,127                     |
| Summit   | \$138  | \$507  | \$1,098                     |
| Cache  | \$391  | \$1,368  | \$2,989                     |
| Duchesne   | \$21   | \$53   | \$133                       |
| Morgan   | \$21   | \$71   | \$157                       |
| Rich   | \$15   | \$53   | \$106                       |
| Davis  | \$1,362                                      | \$4,787  | \$10,006                    |
| Millard  | \$17   | \$52   | \$121                       |
| Uintah   | \$21   | \$55   | \$137                       |
| Daggett  | \$2  | \$4  | \$11                        |
| Garfield   | \$18   | \$60   | \$155                       |
| Iron   | \$153  | \$472  | \$1,094                     |
| San Juan   | \$3  | \$7  | \$19                        |
| State of Utah  | \$12,516                                     | \$44,170   | \$95,016                    |
| Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/states were selected at the time of study region creation. |  |  |                             |
| Study Region : Utah<br>State Annualized<br>MR-4  | All values are in<br>thousands of<br>dollars | Scenario : Annualized<br>Loss-2008 Ground<br>Motions | Earthquake<br>Hazard Report |

Source: FEMA Region VIII; 2010

| <b>Loss Estimates for Buildings (From LHMPs)</b><br><b>Utah Statewide Landslide Risk 2010</b> |  |  |
|---|--|--|
| <b>County – Number of Structures (highest to lowest)</b>                                      | <b>Number of Structures in Areas of Moderate or Greater hazard</b> | <b>Replacement Costs of Residential Units and Annual Sales of Commercial Units</b> |
| Salt Lake   | 30388  | \$6,262,887,678  |
| Weber   | 17609  | \$3,926,990,975  |
| Davis   | 11839  | \$2,278,993,977  |
| Utah  | 11753  | \$1,762,950,000  |
| Washington  | 2823   | \$905,279,402  |
| Summit  | 3054   | \$540,713,300  |
| Morgan  | 1356   | \$276,841,812  |
| Kane  | 881  | \$213,301,739  |
| Cache   | 1099   | \$209,087,058  |
| Iron  | 881  | \$194,175,540  |
| Wasatch   | 757  | \$96,240,000   |
| Tooele  | 391  | \$57,315,737   |
| Sevier  | 553  | \$49,770,000   |
| Garfield  | 182  | \$42,959,231   |
| Box Elder   | 441  | \$39,042,354   |
| Beaver  | 285  | \$22,354,233   |
| Duchesne  | 253  | \$20,240,000   |
| Grand   | 97   | \$12,003,847   |
| Carbon  | 97   | \$7,627,789  |
| Piute   | 92   | \$6,900,000  |
| Uintah  | 66   | \$5,280,000  |
| Wayne   | 17   | \$1,275,000  |
| Daggett   | 13   | \$960,000  |
| Juab  | 1  | \$95,000   |
| Sanpete   | 1  | \$95,000   |
| Emery   | 0  | \$0  |
| Millard   | 0  | \$0  |
| Rich  | 0  | \$0  |
| San Juan  | 0  | \$0  |
| <b>State Total</b>  | <b>84929</b>   | <b>\$16,933,379,672</b>  |

*Figures from the latest Local Hazard Mitigation Plan*

| <b>Loss Estimates for Buildings (From LHMPs)<br/>Utah Statewide Wildfire Risk 2010</b> |  |  |
|--|--|--|
| <b>County – Number of Structures (highest to lowest)</b>                               | <b>Number of Structures in Areas of Extreme or High Hazard</b> | <b>Replacement Costs of Residential Units and Annual Sales of Commercial Units</b> |
| Salt Lake  | 14318  | \$4,451,593,266  |
| Davis  | 4317   | \$1,133,070,054  |
| Utah   | 8752   | \$1,066,773,800  |
| Weber  | 3295   | \$1,007,733,375  |
| Summit   | 5701   | \$962,304,400  |
| Washington   | 2823   | \$905,279,402  |
| Iron   | 2322   | \$530,277,587  |
| Tooele   | 2119   | \$444,770,611  |
| Carbon   | 2337   | \$434,643,208  |
| Kane   | 1777   | \$326,275,285  |
| Morgan   | 1289   | \$267,080,372  |
| Cache  | 923  | \$238,363,505  |
| Wasatch  | 1573   | \$179,572,400  |
| Uintah   | 2428   | \$155,372,800  |
| Grand  | 715  | \$123,851,909  |
| Sevier   | 1574   | \$113,328,000  |
| San Juan   | 442  | \$97,003,423   |
| Rich   | 452  | \$59,177,014   |
| Box Elder  | 541  | \$52,073,841   |
| Juab   | 663  | \$50,388,000   |
| Beaver   | 553  | \$45,596,542   |
| Daggett  | 710  | \$38,600,000   |
| Duchesne   | 462  | \$29,576,960   |
| Sanpete  | 301  | \$22,876,000   |
| Garfield   | 290  | \$19,976,751   |
| Millard  | 109  | \$6,278,400  |
| Piute  | 4  | \$240,000  |
| Emery  | 0  | \$0  |
| Wayne  | 0  | \$0  |
| <b>State Total</b>   | <b>60790</b>   | <b>\$12,762,076,905</b>  |

*Figures from latest Local Hazard Mitigation Plans*

The hazards were then ranked as low, medium, or high priority (see Table I-4) based on the frequency of past occurrences, the magnitude of the impact of past events, the

potential for future impact, perception of threat level, and potential to caused significant damage. The SHMPC also took into account the counties rankings of each hazard.

**Table I-4 Utah Hazards Ranked**

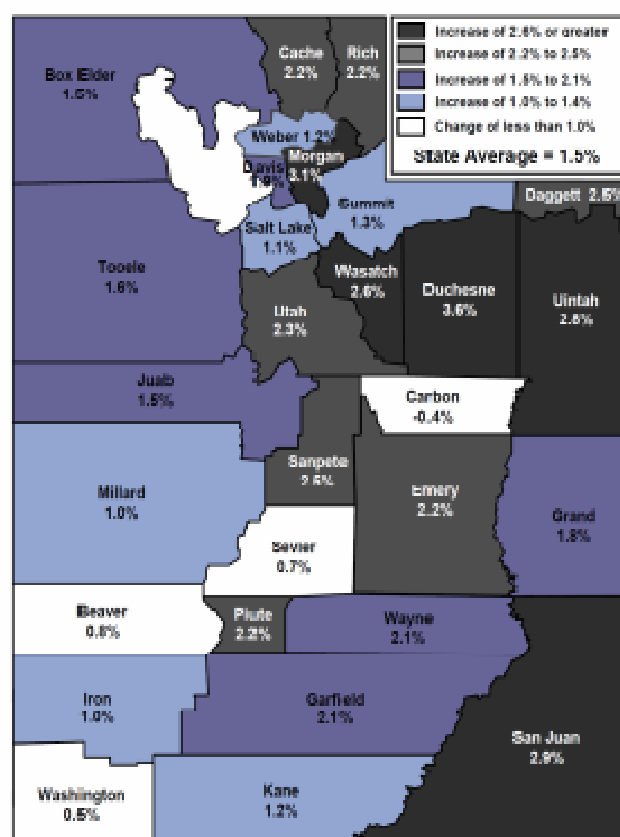
| High Priority             | Medium Priority    | Low Priority  |
|---------------------------|--------------------|---------------|
| Wildfires/Urban Interface | Droughts           | Volcanoes     |
| Floods                    | Severe Weather     | Problem Soils |
| Earthquakes               | Landslides         | Radon Gas     |
|                           | Dam Failure        |               |
|                           | Insect Infestation |               |

## Population

Utah contains 29 counties. The state's capital is Salt Lake City, According to the 2009 Estimated U.S. Census, the population of Utah is 2,784,572. Utah ranks 34<sup>th</sup> most populated state. The state average for population growth 2008 – 2009 was 1.5%. Approximately 80% of the population lives along the Wasatch Front. 2010 U.S. Census data will be available in March 2011.

2011 Outlook—Utah will continue to experience population growth at a rate higher than most states in 2011 on account of strong natural increase in addition to in-migration. Natural increase (births less deaths) is anticipated to add 37,000 people to Utah's population. While net in-migration has slowed since the peak of the economic expansion, Utah's net migration is projected to remain positive at 10,000 people. *Source: EDC Utah 2010*

**Utah Population Growth Rates by County: 2008 to 2009**



Source: Utah Population Estimates Committee

## Population Trends

A total of 42,310 people were added to Utah's population, with 3.7% of this increase coming from people moving into the state. Utah's unique characteristics of high fertility

and low mortality consistently contribute to a strong natural increase. In 2009, the number of births did not surpass the record of 55,357 set in 2008. *Source: EDC Utah 2010*

### Utah's Largest Counties and Associated Population Changes

| Rank | County     | Growth Rate<br>2008 - 2009 | Numeric Change<br>2008 -2009 | Total<br>Population 2009 |
|------|------------|----------------------------|------------------------------|--------------------------|
| 1    | Salt Lake  | 1.1%                       | 11,606                       | 1,042,125                |
| 2    | Utah       | 2.3%                       | 11,810                       | 532,442                  |
| 3    | Davis      | 1.9%                       | 5,741                        | 307,656                  |
| 4    | Weber      | 1.2%                       | 2,723                        | 227,259                  |
| 5    | Washington | 0.5%                       | 756                          | 145,466                  |

*Source UT Population Estimates Committee, 2009 estimates*

### Utah's Largest Population Growth Areas by Increased Growth Rate

| Rank | County  | Growth Rate<br>2008 - 2009 | Numeric Change<br>2008 -2009 | Total<br>Population 2009 |
|------|---------|----------------------------|------------------------------|--------------------------|
| 1    | Uintah  | 2.8%                       | 845                          | 31,291                   |
| 2    | Rich    | 2.2%                       | 51                           | 2,329                    |
| 3    | Piute   | 2.2%                       | 32                           | 1,479                    |
| 4    | Morgan  | 3.1%                       | 302                          | 9,947                    |
| 5    | Wasatch | 2.6%                       | 583                          | 23,428                   |

*Source UT Population Estimates Committee, 2009 estimates*

## Land Use and Development Trends

Following the national trend, farm employment and the number of farms in Utah declined throughout the late 20th century, while agricultural productivity increased. Small farming remains important in the rural areas of the state. Agribusiness is also prominent in other areas in the state. Almost three-fourths of Utah's farm income comes from livestock products, and the remainder from field crops, fruit, and canning crops.

The Great Salt Lake encompasses 1,060,000 acres. Utah is the top producer of brine shrimp. The state also produced \$1.5 billion in cash receipts for crops, livestock, produce, and aquaculture in 2009. Utah encompasses 84,916 square miles, 65 percent of that land is owned by the federal government for national parks, military facilities, mining, public land and other entities. Utah's greatest threats to crop remain drought and invasive species.

Like most of the Western and Southwestern states, the federal government owns much of the land in Utah. Over 70 percent of the land is either BLM land, Utah State Trustland, or U.S. National Forest, U.S. National Park, U.S. National Monument, National Recreation Area or U.S. Wilderness Area.<sup>1</sup> Forests cover nearly one-third of Utah, but only about one-fifth of the forestland is used commercially.

Land cover significantly affects hazard vulnerability. Counties with a large percentage of forest cover are more susceptible to wildfire hazards and invasive species. As

---

## Identifying Hazards

---

urbanization occurs, areas that were once covered with trees and grass are being replaced by impervious surfaces of roads, roofs, and parking lots. This type of urbanization reduces infiltration of rainwater and snowmelt which increases the amount runoff and increases the potential for flash flooding.

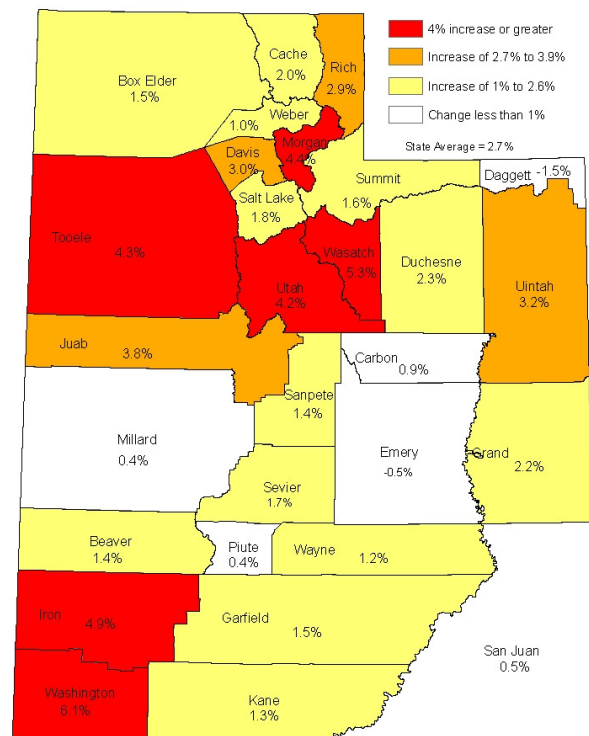
Utah's land use and development is often defined by the state's transportation system. The Salt Lake City International Airport is located just 5 miles from downtown Salt Lake City, is within 2.5 hours from half of the nation's population. In 2008, the airport served over 22 million passengers, making it the 17th largest connecting hub airport in the U.S. With over 700 trucking companies based in the state, Utah is a great location for product distribution. I-80 (extending east to New York City and west to San Francisco), I-15 (extending north to Canada and south to Mexico) and I-70 (extending east to Denver) provide the entire state with great accessibility. About 1,400 miles of railroad track stretch throughout Utah; all lines converge in the Salt Lake and Ogden metropolitan areas allowing second-morning service to 90% of the western U.S. Salt Lake City is the western-most point from which all west-coast cities can be directly served without backtracking. *"Utah at a Glance" -UT EDC 2010*

### Population Growth and Economic Overview From 2008 State Hazard Mitigation Plan

"Employment grew 5.2% in 2006, exceeding the 3.3% long-term average for the second year in a row. This was the fastest growth since 1995. At 4.7%, employment growth is expected to remain very strong during 2007. The rapid job growth during 2006 drove the unemployment rate down to 3.3%, but the gradual deceleration of growth is expected to raise the rate to 3.5% in 2007."

"Each of Utah's major employment sectors grew during 2006 with growth rates ranging from 1.3% in government to 18.1% in construction. Natural resources and mining grew 18.0%, professional and business services grew 7.2%, and financial activity grew 6.1%. The other sectors grew between 3.1% and 4.7%. Utah's average annual nonagricultural pay was \$34,600 during 2006, up 5.4% from 2005. For the third consecutive year, wages exceeded inflation during 2006. From 1994 to 2000, wage growth increased significantly faster than inflation. In

Utah Population Growth Rates by County: 2005 to 2006



Source: Utah Population Estimates Committee

contrast, wages essentially matched inflation from 2001 to 2003. With the economy growing strongly, wages should outpace inflation for a fourth year in a row during 2007, thereby improving Utah's standard of living.”

*“Economic Performance is Up in All Sectors 2006”*

“For the second year in a row, all sectors of Utah's economy performed strongly during 2006. Strong demand and prices boosted agriculture. Continuing low interest rates combined with employment and population growth powered construction to another all time high. The ongoing world geopolitical situation and the role Hill Air Force Base plays in air logistics kept defense growing in Utah. Minerals were up as well, with global economic growth accelerating. Higher energy prices led to more production of natural gas, coal, and oil. Most other sectors had varying levels of improvement.”

Current Economic Overview

Like the nation, Utah’s economy contracted during 2009. Employment, which increased slightly during 2008, declined 4.9% in 2009. Further, the unemployment rate almost doubled, from 3.4% in 2008 to 6.5% in 2009. The housing collapse combined with business caution about building new plants, resulted in construction employment declining 22.6%, after a decline of 12.5% in 2008. *“Utah at a Glance” -UT EDC 2010*

The best way to analyze development trends is through building data and economic growth. The information for Utah Economic Development Corporation (EDC) and the University of Utah’s Bureau of Economic and Business Research support the slow economic and building growth in Utah.

The following information shows the impacts from the ongoing financial recession. While building permits are moving out of negative numbers, it will still take many years to fully recover from the impacts on construction.

**Construction Data – Building Permits, 2008 – 2009 Percent Change**

|                                     |                            |
|-------------------------------------|----------------------------|
| New Dwelling Units                  | -18.7%                     |
| New Residential Valuation           | -40.0%                     |
| New Non-residential valuation       | -47.0%                     |
| Residential Valuation               | -39%                       |
| Non Residential Valuation           | -50.2%                     |
| Total Construction Value            | -35.7%                     |
| Three Top Counties With Most Change | Millard, Sevier and Summit |

*U of U - The Bureau of Economic and Business Research 2009*

### Construction Data – Building Permits, 2009 - 2010 Percent Change

|                                     |                                    |
|-------------------------------------|------------------------------------|
| New Dwelling Units                  | 6.8%                               |
| New Residential Valuation           | 25.6%                              |
| New Non-residential valuation       | -7.8%                              |
| Residential Valuation               | 21.5%                              |
| Non Residential Valuation           | 72.2%                              |
| Total Construction Value            | 21.5%                              |
| Three Top Counties With Most Change | Wayne County, Box Elder and Carbon |

*U of U - The Bureau of Economic and Business Research 2010.*

#### *Analysis 2008 SHMP – 2010 SHMP*

The information from the “Population, Land Use and Develop Trends” supports our current analysis on statewide loss estimates from our 2008 plan update. The state has concluded that with the overall decrease in building permits and general economic decline that our statewide loss estimates have not increased.

#### *Analysis of Local Mitigation Plans*

An additional analysis was performed using local mitigation plans to evaluate changes in overall risk based on a specific hazard. Drought and Severe Weather impact the entire state and they do not necessarily significantly change over time. Development in earthquake hazard prone areas is based on area, changes in population and increase or decrease in development. This can be impacted by local economic conditions. These three hazards could not adequately be evaluated based on these conditions.

The following tables describe a percent of change in structures as they relates to wildfire, landslide and flood prone areas. Current 2009 approved local mitigation plans (WFRC, MAG, BRAG and Five County Regional Mitigation Plans) were used to evaluate identified structures in these hazard prone areas and then that information was compared to the same previous 2004 local mitigation plans.

## Identifying Hazards

| Percent Change in Number of Structures in Landslide Risk Areas<br>LHMP's 2004 - 2010    |                      |
|---|----------------------|
| County  | Percentage of Change |
| Salt Lake   | 465.3%               |
| Weber   | 10.7%                |
| Davis   | 113.7%               |
| Utah  | 0.0%                 |
| Washington  | 941.7%               |
| Summit  | 164.4%               |
| Morgan  | 100.0%               |
| Kane  | 7241.7%              |
| Cache   | 3132.4%              |
| Iron  | 666.1%               |
| Wasatch   | 56.1%                |
| Tooele  | 100.0%               |
| Garfield  | 100.0%               |
| Box Elder   | 100.0%               |
| Beaver  | -11.6%               |
| Rich  | -100.0%              |
| Using LHMPs from 2004 and the most current LHMP   |                      |
| Counties not listed do have updated data on number of structures in wildfire risk areas |                      |
| It is difficult to discern if change is due to growth or with better/different data     |                      |

| Percent Change in Number of Structures in Wildfire Risk Areas<br>LHMP's 2004 - 2010     |                      |
|---|----------------------|
| County  | Percentage of Change |
| Salt Lake   | 143.2%               |
| Davis   | 18.9%                |
| Utah  | 65.4%                |
| Weber   | 86.7%                |
| Summit  | 69.7%                |
| Washington  | -45.4%               |
| Iron  | 51.0%                |
| Tooele  | 130.6%               |
| Kane  | 715.1%               |
| Morgan  | 92.4%                |
| Cache   | 191.2%               |
| Wasatch   | 1.5%                 |
| Rich  | 343.1%               |
| Box Elder   | 77.4%                |
| Beaver  | 368.6%               |
| Garfield  | 21.8%                |
| Using LHMPs from 2004 and the most current LHMP   |                      |
| Counties not listed do have updated data on number of structures in wildfire risk areas |                      |
| It is difficult to discern if change is due to growth or with better/different data     |                      |
|   |                      |

| <b>Change in Percentage of<br/>Structures at Risk to Flooding<br/>LHMP's 2004 -2010</b>   |                                 |
|---|---------------------------------|
| <b>County</b>   | <b>Percentage of<br/>Change</b> |
| Salt Lake   | -46.6%                          |
| Davis   | 100.0%                          |
| Utah  | -45.6%                          |
| Weber   | 100.0%                          |
| Summit  | 3309.1%                         |
| Washington  | 37.6%                           |
| Iron  | 139.0%                          |
| Tooele  | 100.0%                          |
| Kane  | 45.0%                           |
| Morgan  | 100.0%                          |
| Cache   | 57.3%                           |
| Wasatch   | 100.0%                          |
| Rich  | 68.4%                           |
| Box Elder   | 71.1%                           |
| Beaver  | 27550.0%                        |
| Garfield  | 69.8%                           |
| Using LHMPs from 2004 and the most current<br>LHMP  |                                 |
| Counties not listed do have updated data on<br>number of structures in wildfire risk areas.<br>Counties with 100% are counties did not identify<br>structures in the risk area in the previous plan |                                 |
| It is difficult to discern if change is due to growth<br>or with better/different data  |                                 |

## Critical Infrastructure and Facilities

Tracking critical facility, type and associated replacement value is still lacking. By definition a critical facility is one that is considered vital to an area's ability to provide essential services while protecting life and property. A critical facility may be a system or an asset, either physical or virtual. Critical facilities may include, but not be limited to, hospitals, police stations, fire stations, and roadways to name a few.

Currently state critical facilities are not included in the HAZUS data for Utah. To collect the necessary data needed to incorporate these facilities within HAZUS will be a significant undertaking for the state. Utah will continue to pursue developing and performing such a planning task in the future. With FEMA's support this planning task

will be performed through joint planning efforts between the state and FEMA. These efforts may be supported through grants that may become available to the state. Due to existing state resource constraints, the advancement of research and planning for this specific activity will rely heavily on obtaining such support.

We have been able to complete hazard analysis for hospitals and courthouses in the state. Two critical facility reports are found in Appendix O, Utah Court House Natural Hazard Analysis 2010, and in Appendix P, Utah Hospital Natural Hazard Analysis 2010.

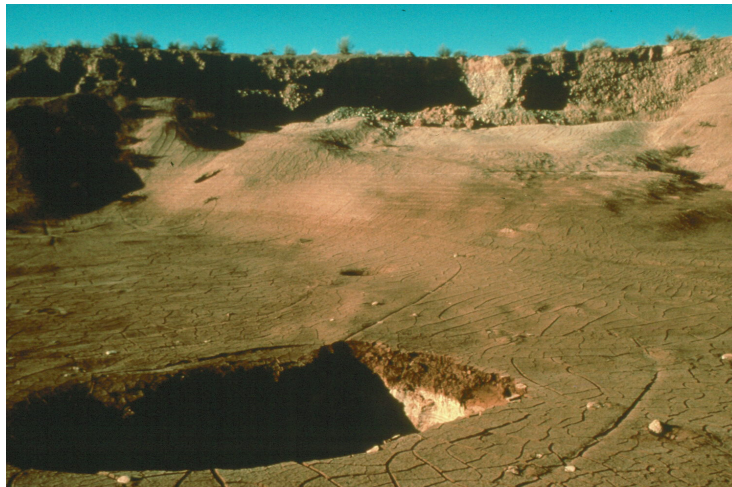
### **Other Hazards**

The identified hazards for which mitigation strategies have been outlined in the following chapters are by no means the only natural hazards, which could affect the State. Other natural hazards could possibly occur, such as volcanic activity, although the probability of such an occurrence is so slight they were not fully considered. We have outlined some of the other hazards below that we felt warranted a little explanation with some possible mitigation measures.

## **Problem Soils**

### **PROBLEM SOIL AND ROCK**

Sandra N. Eldredge, William E. Mulvey, and Gary E. Christenson  
Utah Geological Survey



Karst sinkhole along the Virgin River south of St. George. The sinkhole was enlarged by inflow of water from the Quail Creek Dike failure, 1989 (photo courtesy of B.L. Everitt).

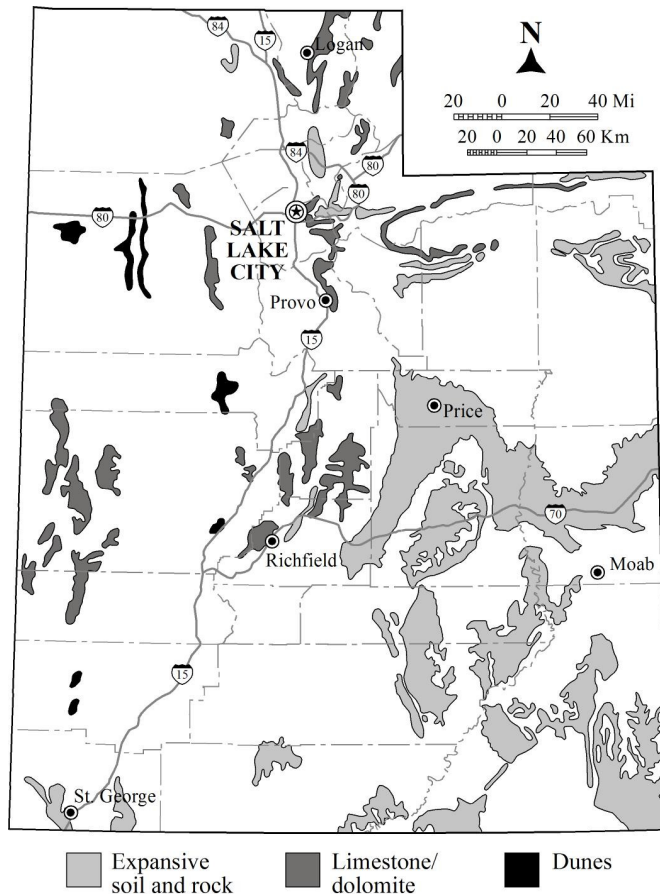
## **OVERVIEW**

Problem soil and rock are a widespread geologic hazard in Utah, covering approximately 20 percent of the state and occurring in many urban areas. Problem soil and rock in Utah include expansive soil, collapsible (hydrocompactable) soil, limestone and karst terrain, gypsiferous soil, soils subject to piping, active sand dunes, peat, underground mines subject to subsidence, and sodium sulfate-rich soil. These geologic materials are susceptible to volumetric changes, collapse, subsidence, or other engineering geologic problems. Human activities, such as adding water and/or loading, can aggravate potentially unstable conditions, and these actions induce the majority of damage to structures.

Geology and climate affect the distribution of problem soil and rock. Some problem materials, such as limestone and expansive soil and rock, cover large parts of the state, whereas other deposits, like sand dunes and peat, have limited areal extent (figure 1).

The two most widespread problems are expansive soil and rock, and limestone and karst terrain. Expansive soil is common in areas of exposed, weathered shale and tuffaceous volcanic rocks in Utah. Karst terrain, developed from the dissolution of limestone, dolomite, and gypsum, is found throughout northern and western Utah, with the greatest concentration in the northeastern part of the state. Gypsiferous soil and rock are common in southwestern Utah and in the Uinta Basin. Sodium sulfate-rich soil is known to occur throughout western Utah. Collapsible soil is most common in alluvial-fan deposits along the mountain fronts from Provo south to the Arizona border.

Other problem soil and rock are more local. Sand dunes occur in isolated areas in the western deserts. Soils subject to piping are found in incised alluvium in canyons of eastern Utah, but occur throughout the state. Peat deposits are found around the shores of Great Salt Lake and Utah Lake, but also locally along mountain drainages partially dammed by glacial moraines and landslides. Subsidence due to collapse of underground mine workings occurs in Park City and Eureka and above active coal mines in the Book Cliffs and on the eastern slope of the Wasatch Plateau.



**Figure 1.** Generalized map of selected problem soil and rock in Utah.

Most of the hazards created by problem soil and rock can be reduced or avoided if they are understood and their extent is known. Recognizing where problem soil and rock are found in the state and taking precautions to minimize their effects can reduce the need for costly corrective measures after damage to structures and roads has occurred.

### DESCRIPTION

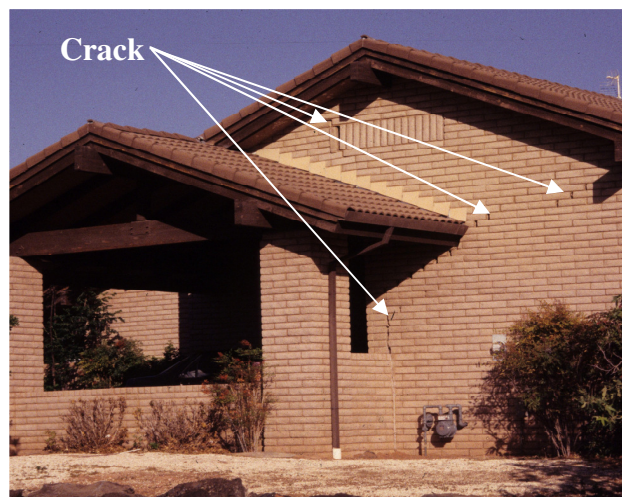
#### Expansive Soil and Rock

Expansive soil and rock contain clay minerals that expand and contract with changes in moisture content. Clays absorb water when wetted, causing the soil or rock to expand. Conversely, as the material dries, the loss of water causes the material to shrink.

The most common clay mineral associated with expansive deposits in Utah is montmorillonite, which can swell to 2,000 times its original dry volume.

Problems associated with expansive materials are foundation cracking, heaving and cracking of road surfaces and other concrete slabs, and failure of wastewater disposal systems. Sidewalks and roads are particularly susceptible to damage. Wastewater disposal systems using soil absorption fields are damaged when clay-rich deposits go through the wet-dry cycle. When dry, cracks develop leaving voids that allow large volumes of water to infiltrate until the soil expands and the voids are closed. The soil then becomes impermeable and systems clog and fail, causing wastewater to discharge at the ground surface.

Expansive soil and rock are the most common type of problem soil and rock in Utah, covering approximately 10 to 15 percent of the state. Certain types of shale are the source of the most expansive deposits, particularly in central and southeastern Utah. Houses and other structures built on expansive shale have suffered extensive damage in Price, Green River, Vernal, and the St. George area (figure 2).



**Figure 2.** Damage to a house from expansive soil and rock in Santa Clara, west of St. George.

Other expansive soil and rock include Lake Bonneville and other deep-lake sediments in the western basins, and volcanic tuffs in the north-central part of the state. Expansive volcanic tuff has damaged structures in Morgan and Weber Counties.

### Collapsible Soil

Collapsible (hydrocompactable) soil causes ground-surface subsidence when the dry, low-density deposits decrease in volume (collapse) when saturated for the first time since deposition. Water introduced from irrigation, water impoundment, lawn watering, alterations to natural drainage, or wastewater disposal can cause this type of soil to collapse and damage structures.

Younger alluvial-fan and debris-flow deposits, generally of Holocene age, and wind-deposited loess, or a gritty, lightweight, porous material composed of tightly packed

grains of quartz, feldspar, mica, and other minerals, are most prone to collapse when wetted. Collapsible soil is common in Richfield and Monroe in the Sevier Valley of central Utah, and near Cedar City and the Hurricane Cliffs in the southwestern part of the state. In Cedar City, approximately \$3 million in damage to public and private structures has been attributed to collapsible soil (figure 3). Collapsible soils are particularly common in alluvial fans at mountain fronts with fine-grained rocks in headwater areas. Climate also plays a role in the distribution of collapsible soils; drier areas such as western and southern Utah provide the best conditions for development of collapsible soil.



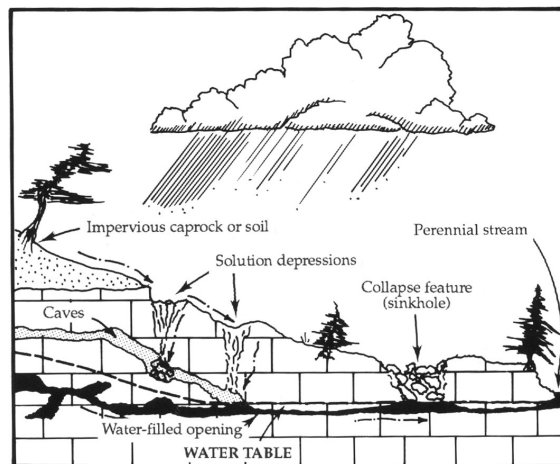
**Figure 3.** Damage to a house in Cedar City caused by collapsible soil.

### Limestone and Karst Terrain

Karst terrain is characterized by closed depressions (sinkholes), caverns, and streams that abruptly disappear underground (figure 4). Karst terrain occurs in rocks such as limestone, dolomite, and gypsum that are susceptible to dissolution by ground and surface water.

Cavernous subterranean openings in karst terrain often collapse, leaving sinkholes at the surface. Structures built in such areas may be damaged by subsurface collapse.

Karst terrain is locally present in northern and western Utah. In northern Utah, surface and ground water are more abundant and karst features are widespread and well developed, especially in the Bear River Range and in the northeastern part of the state. In the Bear River Range area, sinkholes were found beneath a reservoir in



**Figure 4.** Schematic cross section of typical karst terrain showing geology and hydrology. Dash-dot arrows indicate surface- and ground-water flow. Karst features affect surface and subsurface drainage. The cavernous nature of karst terrain provides avenues for contaminants from the surface or shallow subsurface such as wastewater disposal

*systems, landfills, and buried gasoline tanks, to enter the local ground-water system. Contaminants can spread rapidly due to the interconnected system of conduits*

Laketown Canyon in Rich County and in the excavation for the Porcupine Dam in Cache County. The north and south flanks of the Uinta Mountains and the central Wasatch Range between Alpine and Spanish Fork Canyon also contain karst terrain.

Karst features in the Basin and Range Province of western Utah are mostly relict features that may relate to former wetter climates or different ground-water regimes. However, extensive limestone karst aquifers exist in the area and the potential for continued karst development exists where ground water is present in amounts large enough to dissolve limestone or dolomite.

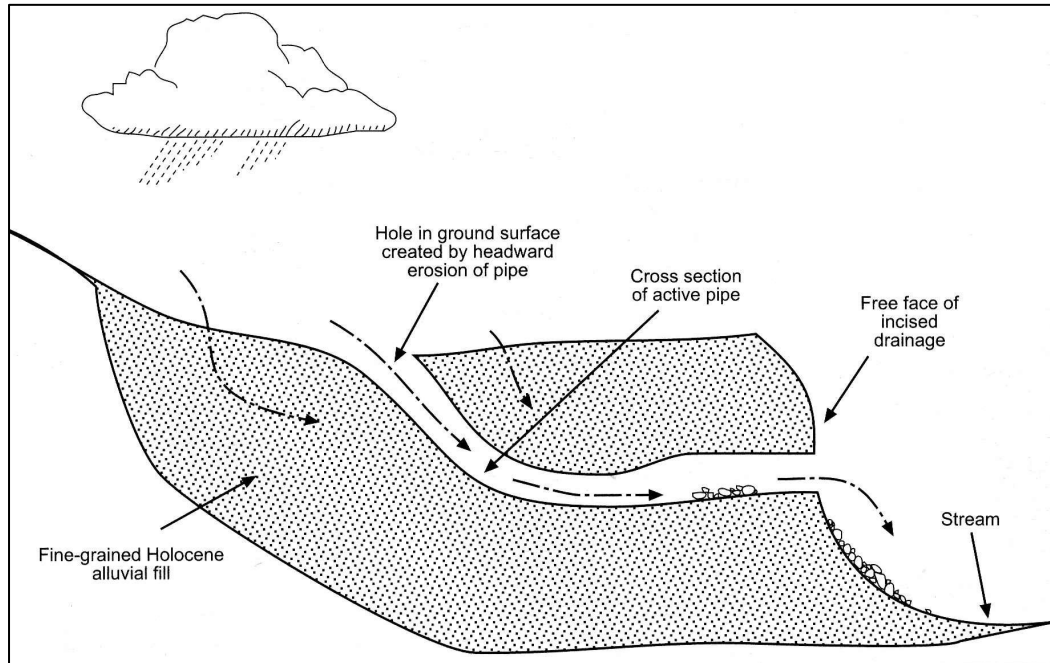
### Gypsiferous Soil and Rock

Gypsum is a primary component of some rocks and the soils derived from them. Gypsiferous deposits are subject to settlement caused by the dissolution of gypsum. Dissolution can induce land subsidence and sinkholes similar to those in limestone karst terrain. When water is introduced by irrigation for crops and landscaping or wastewater disposal systems, underground solution cavities may develop and enlarge, collapse, and form sinkholes. Gypsum is also a weak material with low bearing strength. In addition, when gypsum weathers it forms sulfuric acid and sulfate, which may react with certain types of cement and weaken foundations.

Gypsiferous soil and rock are common in the Uinta Basin near Vernal, and in southwestern Utah, particularly along the base of the Hurricane Cliffs and in the St. George area. In the St. George area, extensive shallow gypsum-rich soils occur as a result of evaporation of sulfate-charged shallow ground water.

### Soil Subject to Piping

Piping is subsurface erosion by ground water that moves along permeable layers in unconsolidated sediment or weakly consolidated rock and exits at a free face (steep bank or cliff) that intersects the layer (figure 5). Removal of fine-grained particles (silt and clay) by this process creates voids that act as channels that direct movement of ground water. As channels enlarge, water in the conduit increases velocity and removes more material, forming a “pipe.” The pipe becomes an avenue for ground water and enlarges as more water is intercepted and sediment is eroded, removing support from the walls and roof of the pipe and causing eventual collapse. Collapse features (sinkholes) form on the ground surface above the pipes, directing even more surface water into the pipes. Eventually, total collapse forms a gully that concentrates erosion along the line of the collapse features.



**Figure 5.** Schematic cross section of a pipe in Holocene-age alluvium. Dash-dot arrows indicate surface- and ground-water flow.

Piping can cause damage to roads, bridges, culverts, and any structure built on deposits subject to piping (figure 6). In areas where piping is common, roads are most frequently damaged because they often parallel stream drainages and cross-cut pipes. Road construction can contribute to piping by disturbing natural runoff and concentrating water along the road surfaces, which allows greater infiltration and potential for pipes to develop. Earthfill structures such as dams may also be susceptible to piping.



**Figure 6.** Sinkhole in road in Montezuma Creek, southeastern Utah, caused by collapse of a soil pipe.

Deposits susceptible to piping are present throughout Utah. Types of material susceptible to piping include fine-grained alluvium and lake deposits, weathered fine-grained rock (siltstone, mudstone, and claystone), and volcanic tuff and ash. Holocene-age alluvial fill in canyon bottoms in the Colorado Plateau physiographic province is a

common material susceptible to piping in Utah. Claystone in this area also develops pipes. Outside the Colorado Plateau, fine-grained marl and silt deposited by Lake Bonneville are susceptible to piping in the western deserts of Utah. Piping of fine-grained embankment material at the base of the Quail Creek Dike near St. George contributed to its failure in 1989. In the Uinta Basin, irrigation of cropland adjacent to incised drainages has caused extensive piping damage.

### Sand Dunes

Sand dunes are common surficial deposits in arid areas where sand derived from weathering of rock or unconsolidated deposits is blown by the wind into mounds or ridges. Dunes occur downwind of source areas and the source areas contribute particles of different composition. In Utah, most dunes consist of silica (quartz) grains, but dunes of gypsum particles and oolites are common in northwestern Utah.

In areas where development encroaches on dunes, several problems may occur. The most common problem is reactivating inactive or vegetated dunes, which may then migrate over roads and bury structures (figure 7). Another problem is contamination of local ground water from wastewater disposal in stabilized dunes, due to the uniform-sized sand grains that make dunes highly permeable but poor at filtering effluent, and due to fine sand, which can clog drain systems. Gypsiferous dunes would be an especially poor wastewater disposal medium as they dissolve when wetted.



**Figure 7.** House in the Escalante Desert of southwestern Utah showing encroaching wind-blown sand reactivated by cultivation on adjacent property.

Valleys in western Utah contain silica dunes composed of quartz grains that were eroded and transported from rock in surrounding mountains. The dunes are typically found on the west side of the mountain ranges. These

dunes extend from the southern end of Tooele and Skull Valleys to the Escalante Desert north of Enterprise.

Gypsum forms as a chemical precipitate during evaporation of sea-water or saline, ephemeral playa lakes; gypsum crystals, moved by the wind, accumulate as dunes. Gypsum dunes are found in greatest concentration in the Great Salt Lake Desert south and east of the Bonneville Salt Flats. They are also found along the lee side of many playas in the basins west of Delta.

Oolitic dunes are composed of calcium carbonate, generally precipitated around a nucleus of fecal pellets from brine shrimp. These round sediment grains are formed in shallow water in terminal lakes (for example, Great Salt Lake) and are exposed as lake

levels fluctuate. During low lake levels, wind reworks beach deposits into dunes. Oolitic dunes are found only in association with oolitic sand beaches along Great Salt Lake and in the Great Salt Lake Desert.

### Peat

Peat is an unconsolidated deposit of partially decomposed plant remains. Peat usually accumulates in areas of shallow ground water and near ponded water where oxygen depletion limits the rate of decay. Low-lying wetlands provide conditions conducive to accumulation of peat.

Peat has a high water-holding capacity and consequently shrinks and oxidizes rapidly when drained. Geologic hazards affecting structures built on peat deposits include rapid oxidation and subsidence when water is removed, and compression and settlement accompanying loading. In the longer term, decomposition of organic material may cause further subsidence.

Due to the generally dry climate of Utah, peat deposits are not widespread. Peat is found in poorly drained areas along the shores of Great Salt Lake, Utah Lake, and in low areas formerly occupied by Lake Bonneville. In mountainous areas, peat commonly forms in canyon bottoms and in poorly drained depressions behind glacial moraines and in the heads of landslides.

### Mine Subsidence

Mine subsidence occurs above both active and abandoned mines in Utah. Underground mining and rock removal leaves voids that, if not adequately supported, can cause collapse of overlying material and subsidence of the ground surface. Utah has a long history of mining, and areas of surface subsidence and sinkholes are common in mining districts. Documented mine subsidence exists in the Park City and Tintic mining districts, where sinkholes have formed due to collapse of underground workings. Structures have been damaged in Eureka (Tintic mining district) where, in one case, a sinkhole 45 feet across and 1400 feet deep was created. Large, active underground coal mines are concentrated in the Book Cliffs and along the eastern slope of the Wasatch Plateau, but the mines are deep and remote so subsidence has not been a major problem. Inactive mines are listed in the Utah Division of Oil, Gas and Mining's abandoned mines data file (approximately 1100 mines).

### Sodium Sulfate

Sodium sulfate is a common chemical precipitate; deposits in soils are derived from wind-borne crystals that formed during evaporation of saline, ephemeral playa lakes. Sodium sulfate also occurs as a primary mineral in bedrock. Soil with a high concentration of water-soluble sulfates exhibits an expansive phenomenon resembling that of expansive clays and frost heave. Problems associated with sodium sulfate in soil are similar to those experienced in areas of expansive soil and rock.

Sodium sulfate derived from playa evaporation is common in the Basin and Range Province of western Utah. Sodium sulfate derived from bedrock occurs in

Duchesne County and enters into the local surface and ground water. Sodium sulfate-rich soil is present in the highlands north of St. George and in dams impounding stock ponds in the Blue Creek-Howell watershed in Box Elder County. Most sodium sulfate in northern Utah is derived from the fine-grained, deep-water sediments left by Lake Bonneville.

### **MITIGATION**

Most of the hazards created by problem soil and rock can be reduced or avoided once their extent is known. Recognizing that problem soil and rock cover parts of the state and taking precautions to mitigate the potential hazards can reduce the need for costly corrective measures after damage to structures and roads has occurred. The majority of damage to structures results from human activities, usually through addition of water or by loading or excavation, which aggravate potentially unstable conditions.

Mitigation measures for expansive soil and rock include special foundation designs, gutters and downspouts that direct water away from foundation slabs, landscape vegetation that does not concentrate or draw large amounts of water from the soil near foundations or require irrigation, and insulated floors or walls near heating or cooling units to prevent evaporation that could cause local changes in soil moisture. If collapsible soils are suspected to be present, soil consolidation tests can be performed. Mitigation methods include pre-soaking and/or compacting, excavating and backfilling with suitable material, and landscaping to direct water away from a structure.

Avoiding areas underlain by limestone and dolomite is the best method of preventing ground-water contamination and collapse problems in karst terrain. If this is not possible, preconstruction planning and design of wastewater disposal systems based on thorough geologic and hydrologic investigations can avoid areas of potential sinkholes and prevent ground-water pollution. Soil tests can determine the presence of gypsum. If gypsum is present, the outer walls of structures can be coated with impermeable coatings, special types of concrete can be used that resist damage from gypsum, runoff from roofs and gutters can be directed away from structures, and landscaping close to a structure can avoid plants that require regular watering.

Limiting the degree to which natural drainage in soil susceptible to piping is disturbed by construction can reduce damage caused by piping. Proper drainage along roads and around structures is the most cost effective and successful mitigation procedure. Active dunes should be avoided because of their constant movement and unstable nature. Usually, dunes are a maintenance problem and do not preclude development. In general, peat deposits should be removed or avoided.

Risk from mine subsidence is reduced by enforcement of laws that require mining companies to devise mining methods that reduce the potential for surface subsidence. If subsidence occurs, the mine is required to alter their mining methods to prevent further subsidence. Mine maps may be available in areas of abandoned mines to avoid areas of potential collapse. Mitigation measures for sodium sulfate-rich soils are similar to those listed for expansive soil.

### Where to Find Additional Information

<http://soils.usda.gov/> Regional and local soil surveys, with information on soil types and engineering properties, are available from the Natural Resources Conservation Service (formerly Soil Conservation Service).

<http://geology.utah.gov/> Engineering-geologic information and geologic-hazards maps, including problem soil and rock maps for some areas, are available from the Utah Geological Survey.

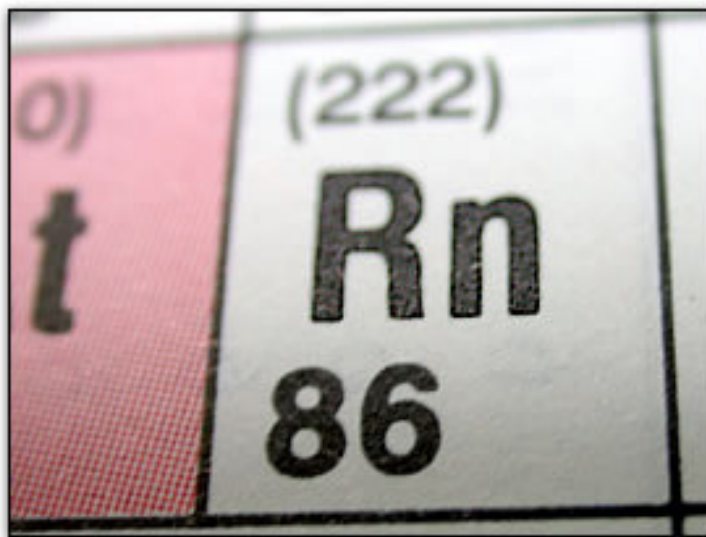
<http://www.ogm.utah.gov/> Listings of abandoned mines and their conditions can be obtained from the Utah Division of Oil, Gas and Mining.

## Radon Gas

### **Radon: How to Protect Your Home and Family**

David Neville, M.S., RMS and John Hultquist, R.M.S.

Department of Environmental Quality  
Division of Radiation Control  
Indoor Radon Program



## **OVERVIEW**

Most people have heard about radon, usually in chemistry class when noble gases are discussed, but few know the importance it has in our daily lives. Radon is a radioactive gas released from the nuclear decay process of uranium and radium, which are trace elements in many soils. Because radon is a radioactive gas that is tasteless, invisible, and odorless, it presents unique challenges in minimizing our daily exposure to this naturally occurring radiation. This chapter will discuss the history of radon, the health effects of radon, how to test for radon, and how to mitigate a radon problem.

### History of Radon

The history of radon begins with a theoretical physicist name Friedrich Ernst Dorn. While studying the natural radioactive decay of radium, he detected a radioactive gas and called it radium emanation. It has been called radon since the 1920's.

Further understanding of radon came out of Bohemia and the four corners area of the United States, where uranium mining occurred in large quantities. Because radon is a natural radioactive decay product of uranium, uranium mines may have high

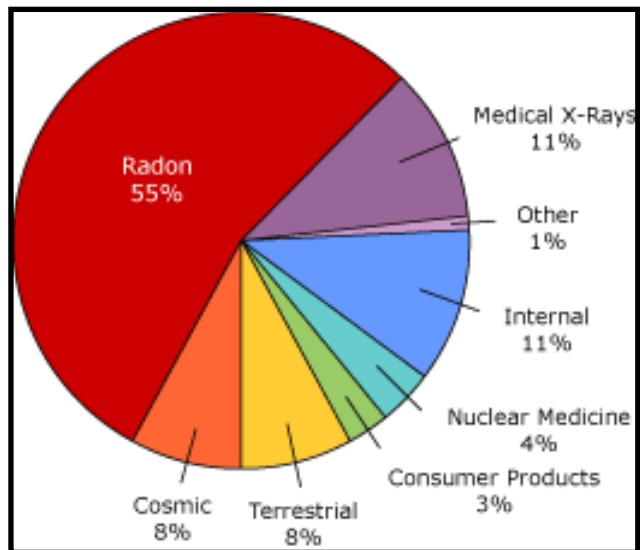
concentrations of radon and its highly radioactive decay products. In the mid-1950s, many uranium miners in the Four Corners region contracted lung cancer and other pathologies as a result of exposure to high levels of radon. The increased incidence of lung cancer was particularly pronounced among Native American and Mormon miners because those groups normally have lower rates of lung cancer. Unfortunately, safety standards requiring expensive ventilation were not widely implemented or regulated during that period.

The danger of radon exposure in dwellings was discovered in 1984 with the case of Stanley Watras. While entering work at the nuclear power plant in Limerick Township, Pennsylvania, Watras triggered the radiation alarms. For two weeks epidemiologists and radiation experts searched for the source of the radiation contamination. They were shocked to find that the source was not related to the nuclear plant. Rather, the culprit was astonishingly high levels of radon, 2,700 pico-curies/liter (pCi/L), in the basement of his home. The risks associated with living in his house were estimated to be equivalent to smoking 135 packs of cigarettes every day.

Following this occurrence, national radon safety standards were set and radon detection and ventilation became a standard homeowner concern on the Eastern seaboard. In 1988 Ronald Reagan signed into law the Indoor Radon Abatement Act (IRAA), establishing a long-term goal that indoor air be as free from radon as the ambient air outside buildings. The standard was set at 0.4 pCi/l. This law provided grants and financial incentives for states and universities to establish training centers, radon programs, surveys, public information about radon, and construction standards to prevent radon from entering residences.

### Why Radon is a Concern

Radon is a radioactive gas released from the nuclear decay process of uranium and radium, which are trace elements in many soils. It is classified by the EPA as a Group 1 (known human) carcinogen and is considered the leading cause of non-smoking lung cancer in the United States (Carmona, 2005). In noting the average dose of radiation to humans, the National Council on Radiation Protection and Measurements (NCRP) indicates that most people receive their annual dose of background radiation from radon (see figure 1).



**Figure 1.** Average Human Radiation Dose Per Year.

The major health concern related to radon is lung cancer. The National Cancer Institute (NCI) notes that lung cancer is the leading cause of cancer deaths in both men and women (Edwards, et. al.

2005). Overall, radon is responsible for about 21,000 lung cancer deaths every year. About 2,900 of these yearly deaths occur among people who have never smoked. According to estimates of the Environmental Protection Agency (EPA), “Radon is the number one cause of lung cancer among non-smokers” (EPA, 2005). Because radioactive alpha emissions are the principal mode of decay for radon and its progeny, the short distances traveled by this form of ionizing radiation do

not allow it to reach other organs. Unlike radon, the progeny are not gaseous, but rather particulate in nature. They can attach themselves to other particulates suspended in the air and, once inhaled, they reside in the lung and irradiate lung tissue based on their decay and associated radioactive half-lives.

On January 13, 2005, the U.S. Surgeon General, Dr. Richard H. Carmona issued the second national health advisory on radon urging home owners to test for radon. He stated: “Indoor radon is the second-leading cause of lung cancer in the United States, and breathing it over prolonged periods can present a significant health risk to families all over the country....It’s important to know that this threat is completely preventable. Radon can be detected with a simple test and fixed through well-established venting techniques” (Carmona, 2005).

Radon kills more people than drunk driving, drowning, or residential fires each year (see figure 2).

The U.S. Surgeon General, World Health Organization (WHO), Environmental Protection Agency (EPA), National Academy of Sciences, American Lung Association, American Cancer Society, National Cancer Institute, and the National Institutes of Health all agree that high levels of radon present a health risk and should be reduced.

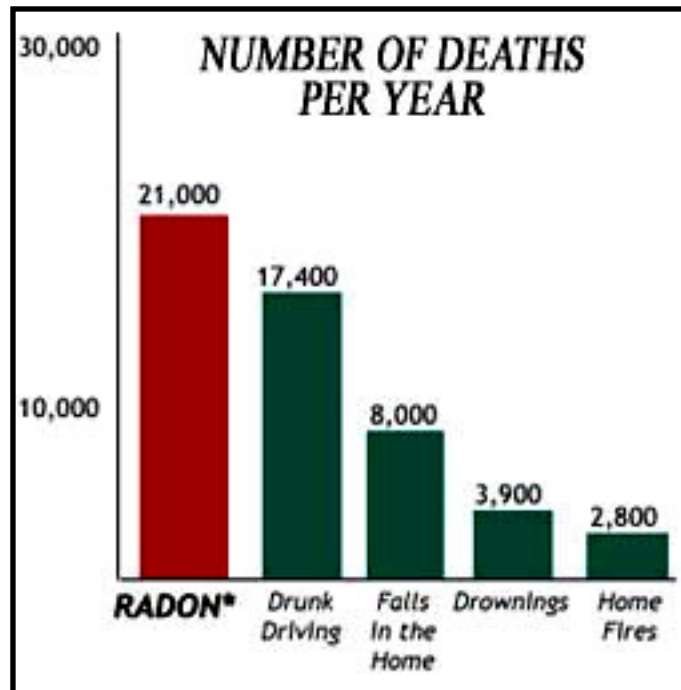


Figure 2. Deaths Per Year.

### How Radon Enters Buildings

In order for radon to enter a home or building, there must be a passageway through which the radon can travel and a driving force to draw the radon in. The most common passageways into structures are:

- Cracks in solid floors
- Construction joints
- Cracks in walls
- Gaps in suspended floors

- Gaps around service pipes
- Cavities inside walls
- Water supply connections

The most common way that radon enters a home is when lower indoor air pressure draws air from the soil, bedrock, or drainage system into the house (EPA, 2007). If cracks, holes, and pores in the foundation are open to the soil, radon will be drawn indoors.

The driving force is usually a combination of air pressure differentials. All of us have likely experienced pressure differentials inside buildings. When opening the doors to many commercial buildings, a gust of wind from inside seems to come rushing outside. This positive pressure is an excess of air from within the building and works to heavily reduce radon and other soil gases from entering buildings. The opposite is also true. When doors inside many residences are not shut all the way, outside air is sucked inside the home. This negative pressure is a shortage of air from within the residence and works to actively increase radon and other soil gases inside the home.

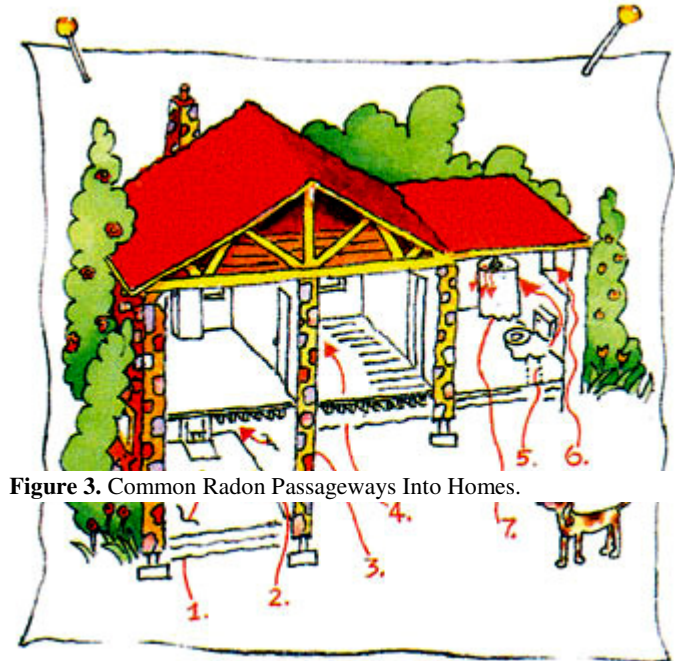


Figure 3. Common Radon Passageways Into Homes.

Pressure differentials can occur naturally when low-pressure weather systems are accompanied by heavy rain. The resulting rapid rise in the underground water table can displace a large amount of soil air, generating positive pressure in the soil around building foundations. The displaced soil air mass is forced to equalize with atmospheric air through a building. In these conditions, radon can enter a home, often accumulating to elevated levels.

### Radon Testing

Testing for radon is simple and easy. Test kits can be purchased from *Lowe's* or *The Home Depot* for a nominal charge. You can even order test kits online from [www.utahsafetycouncil.org](http://www.utahsafetycouncil.org) for about \$12. To ensure your results are accurate, special care should be taken to observe the following closed house conditions:

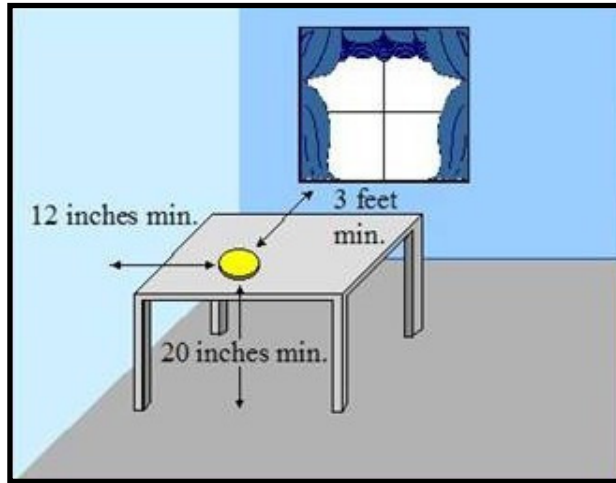
- Closed windows
- Doors only opened for entry and exit
- No Swamp Cooler Operation
- Furnace or central air on normal, not continuous

When using a radon test kit, make sure to place it in an appropriate place to receive accurate test results. Generally speaking, you should test where you live and sleep. Bedrooms and family rooms are good places to test for radon. Testing in kitchens, bathrooms, year supply rooms, cellars, storage areas, etc. is not recommended. Additionally, during storms a drop in atmospheric pressure can enhance the pressure gradient between soil and air, increasing radon emanation from the soil and resulting in higher than normal radon testing results.

Proper placement of the test kit is important. Make sure to place it:

- 20" off ground
- 36" from window
- 12" from wall
- 4" from other objects

Short-term tests provide reliable results. If your results are higher than 4.0 pCi/L, it is advisable to confirm those results by performing another short-term test. Long term testing takes longer than 90 days and provides the most accurate readings over a season. Additionally, when testing for long-term results you do not need to live under closed house conditions. Normal living conditions apply for long-term tests. For real estate transactions, time is of the essence and a short-term test will tell you what you need to know. Professional radon measurement specialists can give accurate radon readings usually within 48-72 hours.



**Figure 4.** Proper Radon Test Placement Within a Room.

### Results of the Radon Test

People often want to know what is considered a “safe” level of radon. The answer is that there is no “safe” level of radon in homes. There is some risk associated with all radon because of its radioactive nature. Since radon in the outside air is measured at 0.4 pCi/L, anything above that increases your dose of radiation beyond what you would be likely to receive naturally. The EPA has set guidelines to understand radon levels better.

If your radon levels are 2.0 pCi/L and below, you realistically have your levels as low as reasonably achievable and no action is needed. If your radon levels are between 2.0 and 4.0 pCi/L, you should consider taking some action to reduce your radon levels. If your radon levels are 4.0 pCi/L and above, you should mitigate your home. The EPA action level of 4.0 pCi/L is 10 times the levels found in nature. All homes can be reduced to below 4.0 pCi/L with simple and effective mitigation strategies.

### MITIGATION

A basic radon mitigation system consists of entry point seals, a radon exhaust pipe, a fan, and a failure-warning device (see figure 5). The best way to reduce radon in the home is to prevent it from getting inside. By collecting it prior to entry into the building and discharging it into the outside air, the risks associated with radon are greatly reduced. Furthermore, once radon is inside of a home it can be reduced by dilution with increased ventilation. Filtering air particulates from the air can also reduce the effects of radon and RDPs and can also reduce radon levels. However, collecting radon-laden soil gas before entry into the building is the best way to mitigate a radon problem.

Radon mitigation systems were created to prevent radon from entering a home. They are also designed with the homeowner in mind; while being extremely effective in reducing radon, they also boast these simple, cost-saving features:

- Reduction in other soil gases and volatile organic compounds (VOC's)
- Reduction in moisture, mold, and mildew concerns
- Improvements to indoor air quality
- Unobtrusive and quiet
- Durable and capable of indicating system failure
- Economical to install, operate, and maintain.

In 2006, the EPA joined forces with the American Society for Testing and Materials International (ASTMI) in implementing standard practices for radon mitigation systems in existing low-rise residential buildings (E 2121-03). Methods that effectively reduce radon entry via soil depressurization include a fan system and sub-slab depressurization. As a general rule, the following installation techniques are recommended:

- When placing the piping into the concrete slab, remove 10-15 gallons of dirt, install the 4" PVC piping, and test for suction with a U-tube.
- Placement of a fan must be restricted to areas without conditioned space, e.g. not in crawl spaces, basements, garages with overhead bedrooms.
- The radon exhaust should be 10 feet above the ground with a rodent screen, away from neighboring homes, two feet above the lowest eave of the home, and away from

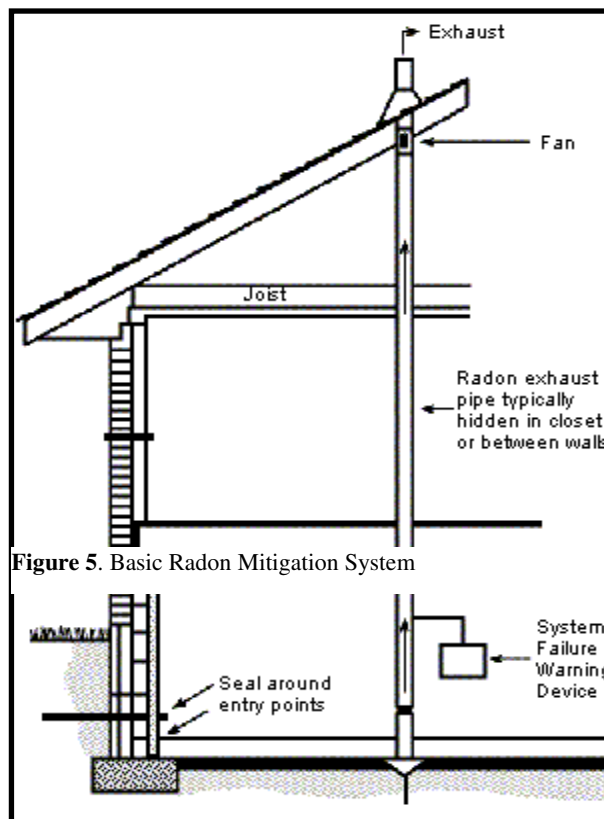


Figure 5. Basic Radon Mitigation System

windows. Nobody wants to have a radon system that pumps radon back into the house via a new pathway.

### Cost of Radon Mitigation

The cost of a radon mitigation system is similar to the cost of installing a new furnace or replacing your washer and dryer. \$1,200-\$1,800 is an average cost in Utah, depending, of course, upon the type of foundation and the size of the home. Homes with crawl spaces generally cost more to mitigate, and larger homes may require multiple suction points, thus increasing the cost. Of course, the most cost efficient way to prevent radon from entering homes is by installing a passive system at the time of construction.

By building new homes with radon resistant construction techniques, homeowners can save money and reduce their radon risk at the same time. The additional cost for building a new home with radon resistant techniques is approximately \$400-\$600. By wiring for a fan in case it's needed later, builders can keep the costs of turning a passive system into an active system low, too.

Typical fan installation is about \$300.

Ventilation methods can also assist with reducing and diluting radon. By increasing the fresh air take-up inside a building, radon and other indoor air contaminants are reduced. Caulking cracks in walls and floors can also aid in reducing radon by improving the vacuum within a home and reducing the loss of interior air.

### CONCLUSION

Radon is a radioactive, tasteless, odorless, invisible gas. It can be found all over the United States and the world. Though radon is found in the outside air at low levels (0.4 pCi/L), inside of homes it can accumulate to high levels, thus increasing the risk of lung cancer. In accordance with advice given by the US Surgeon General, all homes should be tested for radon. Homes with high levels of radon (above the EPA action level of 4.0 pCi/L) should be appropriately mitigated.

Additional information can be found at:

The Utah Department of Environmental Quality:

<http://www.radon.utah.gov>

The Environmental Protection Agency:

<http://www.epa.gov/radon>

**"Indoor radon is the second-leading cause of lung cancer in the United States and breathing it over prolonged periods can present a significant health risk to families all over the county. , , ,It's important to know that this threat is completely preventable. Radon can be detected with a simple test and fixed through well-established venting techniques."**

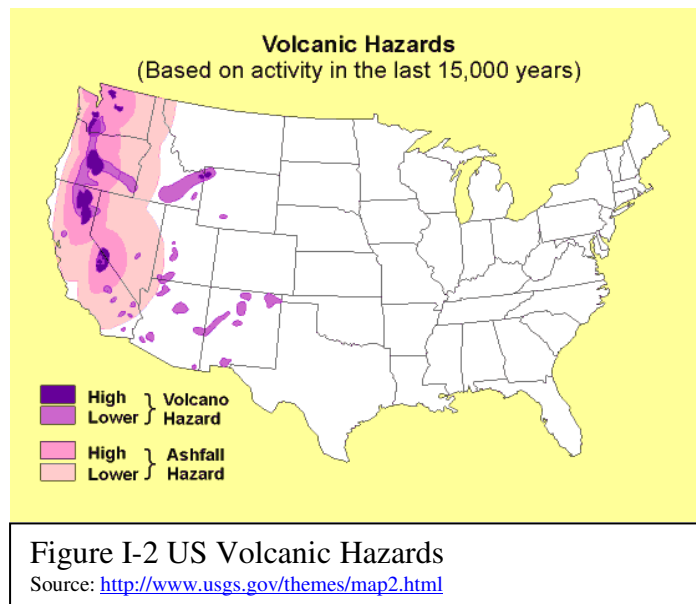
**Richard Carmona, 2005  
U.S. Surgeon General**

The American Lung Association  
<http://www.lungusa.org>

The American Cancer Society  
<http://www.cancer.org>

### Volcanoes

Volcanoes are created when internal forces in the Earth, cause heated, melted rock (magma) to rise to the surface. First collecting in magma chambers, some of the magma eventually pushes upward through cracks (vents) to the Earth's surface. As the magma reaches the surface, it loses some of its gases and turns into lava. Volcanoes are created by the release and build-up of lava and other materials. Volcanoes have varied shapes and sizes, but are divided into three main kinds depending on the type of material that reaches the surface and the type of eruption that ensues. Utah has all three types.



#### 1. *Composite or Stratovolcanoes*

Composite volcanoes (stratovolcanoes) develop from repeated explosive and non-explosive eruptions of tephra (airborne lava fragments that can range in size from tiny particles of ash to house-size boulders) and lava that build up layer by layer. These volcanoes are the largest and form symmetrical cones with steep sides. Some composite volcanoes in Utah are in the Tushar Mountains (Mount Belknap, for example) in Piute County. Now extinct, they are too old (between 32 and 22 million years) to maintain the classic volcanic shape of their modern-day counterparts, such as Mount Hood and Mount St. Helens in the Cascade Range along the northwestern coast of the United States.

#### 2. *Shield Volcanoes*

Shield volcanoes form from "gentle" or non-explosive eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides. The low-profile shape resembles a warrior's shield. In Utah a good example is the one-million-year-old Fumarole Butte in Juab County. Currently active volcanoes of this type are found in the Hawaiian Islands.

### 3. *Cinder Cones*

Cinder cones build from lava that is blown violently into the air and breaks into fragments. As the lava pieces fall back to the ground, they cool and harden into cinders (lava fragments about 1/2 inch in diameter) that pile up around the volcano's vent. Cinder cones are the smallest volcanoes and are cone-shaped. Cinder cones are found in many areas of Utah including Millard, Iron, Garfield, Kane, and Washington Counties, and they vary in age. The youngest, only about 600 years old, are in the Black Rock Desert in Millard County.

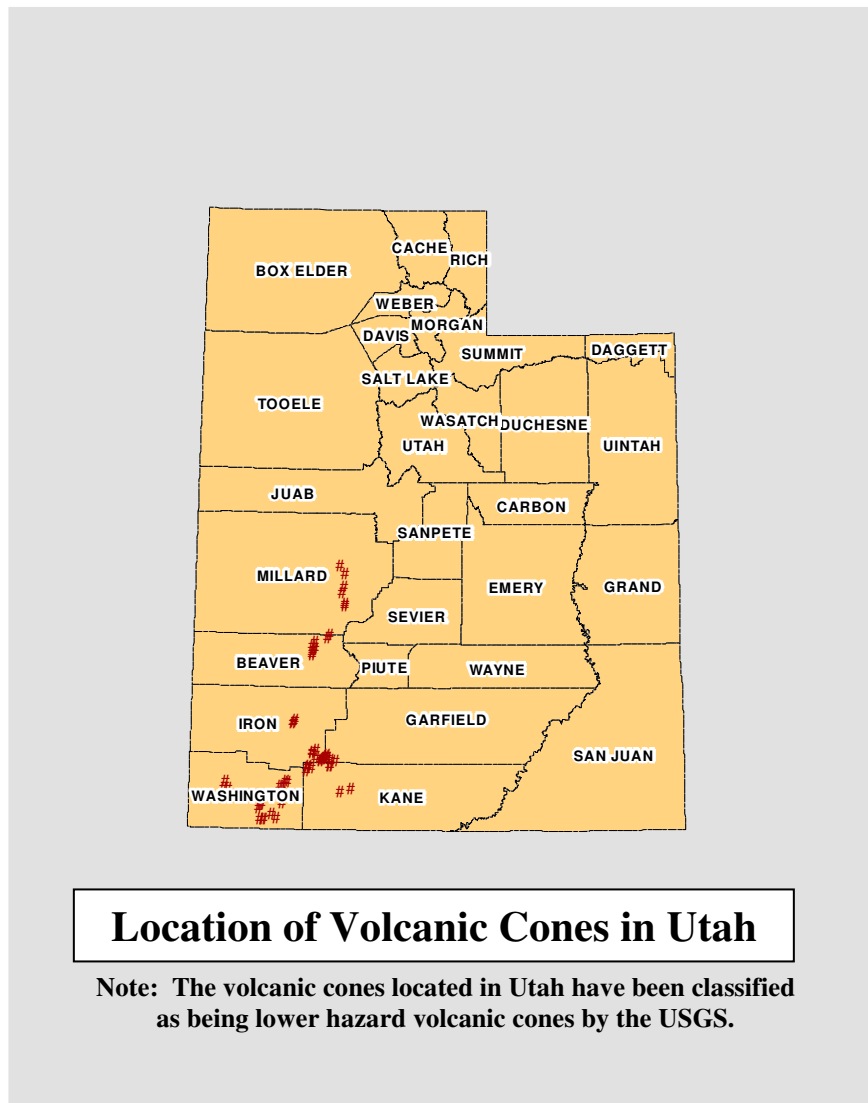
There have been several major volcanic eruptions worldwide during the past 25 years. Among these were the eruption in 1980 of Mt. St. Helens in Washington State followed by the 1982 eruption of El Chichón in Mexico, the 1990 eruption of Mt. Pinatubo in the Philippines, and the 1995 eruption of the Soufriere Hills Volcano in Montserrat all generated unprecedented awareness to the potential calamitous effect of volcanic hazards. Fortunately, these events have not had any significant effect on Utah residents

Over 270,000 human fatalities have resulted worldwide from volcanic activity during the past 500 years. Information from the Utah Geological Survey indicates that while most of the deaths world-wide have been related to the eruptions of high-silica alkali composition volcanics, fatalities and property damage can result from basaltic and rhyolitic flows, plugs and dome, features that are typical of volcanism throughout Utah, particularly southwestern Utah.

When discussing inclusion of volcanic hazards into this mitigation plans several problems arose. Because of the intermittent nature of volcanic eruptions and lengthy recurrence intervals, people tend to minimize volcanic hazards as a threat to property and lives, which is understandable. While geomorphically fresh features and textures, geothermal anomalies, and recent eruptive histories present convincing arguments for the continuation of volcanic events in Utah. This mitigation plan does not address volcanic risk for the reason that:

- The only current hazard would strictly be from local, small cinder cone basaltic eruptions.
- Rather than local events, remote eruptive centers present Utah's most imminent and potentially damaging volcanic hazard. Areas east of Mt. St. Helens were the recipients of ash fallout.
- Long recurrence intervals
- Advances in science have provided long warning times
- Any ash or lava event to affect Utah would be localized, a safe distance from population centers, and would likely have an advanced warning.

The active volcanic centers in Utah include the Escalante Deserts in the Basin and Range Province; the High Plateaus and adjacent areas in the Colorado Plateau Province; and the Pine Valley Mountains-St. George Basin and surrounding areas.



### River Channel Morphology

River channel morphology is a geomorphologic process that results from hydrological processes that naturally occur over a landscape. Some examples of these hydrological processes, such as flooding and stream sediment transportation, can greatly alter the landscape in the vicinity of a stream. Factors that control stream flow, sediment transportation, flow velocity, and channel gradient can change in response to tectonic, climatic, and anthropogenic factors (Summerfield, 1991). Changes to these channels, whether natural or human-induced, can potentially threaten residences, businesses, and other man-made structures that are built too close to streams. In the state of Utah, river channel morphology is a common occurrence. Flooding in January 2005 resulted in a Presidential Disaster Declaration. An estimated \$300 million dollars in damages was

sustained along the Santa Clara and Virgin Rivers in Washington County. 30 homes were destroyed in the flood and another 20 homes were significantly damaged (NCDC, 2005).

Three major river channel types exist in the state of Utah. The next sections discuss the river channel types and their morphology characteristics as described by Summerfield, 1991.

### *1. Bedrock Channels*

Bedrock channels are channels that are cut into rock. This type of channel is found in the canyon areas of Southern Utah, such as the San Juan River in Goosenecks State Park. These channels generally experience gradual modification to their stream channels and modification to the channel shape occurs over a very long period of time. Rapid lateral shifting of the streambed may occur, however, in areas along the streambed in which the bedrock is only weakly resistant.

### *2. Alluvial Channels*

Alluvial channels are streams in which the bed and banks of the streams are composed of sediments transported by the river. This channel type has the potential to experience dramatic changes to its stream banks in the event of increased stream flow. Massive changes to the stream channels can result from the erosion of weakly resistant alluvium due to increased stream flow rates. An example of this type of stream channel morphology occurred along the banks of the Virgin and Santa Clara Rivers in Southwestern Utah during the January 2005 flood.

### *3. Semi-controlled Channels*

Semi-controlled channels are channels in which certain areas of the channel are locally controlled by bedrock or resistant alluvium. These channels tend to be stable in the areas dominated by bedrock and resistant alluvium, and unstable in areas of weakly resistant alluvium. Slow, lateral movement of the channel is common in areas of bedrock and resistant alluvium and rapid changes to the channel occur in areas of weakly resistant alluvium in the event of flooding.

Factors that impact the acceleration of stream bank erosion processes include:

1. **Amount and duration of a precipitation-producing event:** Heavy and/or lengthy rainfall events can cause flooding which may accelerate stream flow and subsequently hasten stream bank erosion. Flooding following a wildfire occurrence can greatly accelerate the erosion process along streams and its surrounding terrain.
2. **Texture of soil:** Certain soil types, such as sandy and silty soils typically erode faster than moist clay soil types.
3. **Gradient of the slope:** Steeper slopes tend to be more erosive than lower-angle slopes.
4. **Ground cover from vegetation.** Vegetation typically helps to de-accelerate the erosion process. Roots from vegetation allow the soils to remain more cohesive during rainfall events. Areas, especially riparian buffers surrounding streams, help

channels maintain their integrity during rainfall events. Removal of vegetations, especially riparian vegetation, can greatly accelerate the erosion process of stream banks.

5. **Land use:** Land use practices can enhance or depress the rate of stream bank erosion. Construction of homes near stream channels, suppression of natural vegetation along stream, and overgrazing by livestock are example of land use practices that may assist in the acceleration of stream bank erosion.